NEW ENGLAND WATER WORKS ASSOCIATION.

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This Association as a Body, is not responsible for statements or opinions of any of its members.

QUARTERLY MEETING.

AT YOUNG'S HOTEL, BOSTON, DECEMBER 12TH, 1888.

The following members and guests were present:

Chas. A. Allen, City Engineer, Worcester, Mass.; Solon M. Allis, Supt.; Malden, Mass.; Phinehas Ball, C. E., Worcester, Mass.; Rev. D. N. Beach, Cambridge, Mass.; Hon. Chester W. Kingsley, Cambridge, Mass.; William S. Barbour, City Engineer, Cambridge, Mass.; Joseph E. Beals, Registrar, Middleboro, Mass.; Geo. H. Bishop, C. E., Middletown, Conn.; Dexter Brackett, C. E., Boston, Mass.; J. Henry Brown, Boston, Mass.; Chas. E. Chandler, C. E., Norwich, Conn.; Geo. F. Chace, Supt., Taunton, Mass.; Lucas Cushing, C. E., Boston, Mass.; Geo. A. Cushing, C. E., Hingham, Mass.; H. W. Conant, Supt., Gardner, Mass.; R. C. P. Coggeshall, Supt., New Bedford, Mass.; Edwin Darling, Supt., Pawtucket, R. I.; Albert B. Drake, C. E., New Bedford, Mass.; Prof. Thos. M. Drown, Boston, Mass.; Geo. E. Evans, City Engineer, Lowell, Mass.; F. F. Forbes, Supt. Brookline, Mass.; Albert S. Glover, Water Registrar, West Newton, Mass.; Wm. R. Groce, Supt., Rockland, Mass.; J. A. Gould, Jr., C. E., Boston, Mass.; E. H. Gowing, C. E., Skowhegan, Me.; Frank E. Hall, Supt., Quincy, Mass.; Joseph C. Hancock, Supt., Springfield, Mass.; John L. Harrington, Cambridge, Mass.; John Harris, Water Commissioner, Waltham, Mass.; V. C. Hastings, Supt., Concord, N. H.; Horace G. Holden, Supt., Nashua, N. H.; Patrick Kieran, Supt., Fall River, Mass.; Geo. A. Kimball, C. E., Boston, Mass.; A. W. Locke, Haverhill, Mass.; Chas. W. Morse, Supt., Haverhill, Mass.; James W. Morse, Supt., Natick, Mass.; Hiram Nevons, Supt., Cambridge, Mass.; Albert F. Noyes, C. E., West Newton. Mass.; Paul P. Patton, Water Com'r., Salem, Mass.; Geo. J. Ries, East Weymouth, Mass.; Walter H. Richards, Supt., New London, Conn.; W. W. Robertson, Water Registrar, Fall River, Mass.; Chas. W. S. Seymour, Supt., Hingham, Mass.; Wm. B. Sherman, C. E., Providence, R. I.; Solon F. Smith, Supt., Grafton, Mass.; Geo. A. Stacy, Supt., Marlboro, Mass.; Prof. Geo. F. Swain, Boston, Mass.; Chas. H. Swan, C. E., Boston, Mass.; Lucien

ERRATUM:

In line 5, page 104, read James L. Gale.

A. Taylor, C. E., Boston, Mass.; D. N. Tower, C. E., Cohasset, Mass.; C. H. Truesdell, C. E., Central Village, Conn.; Chas. K. Walker, Supt., Manchester, N. H.; Joseph Waters, Water Com'r., Fall River, Mass.; Geo. E. Winslow, Supt., Waltham, Mass.; J. S. Winslow, Supt., Pittsfield, Mass.; Wm. Gibson, Jr., The Engineering and Building Record, New York; F. W. Shepard, Fire and Water, New York; H. R. Barker M'fg. Co., Lowell, Mass.; Geo. F. Blake M'fg. Co., Boston, Mass.; A. H. Brodrick, Chadwick Lead Works, Boston, Mass.; Coffin Valve Co., Boston, Mass.; Dean Steam Pump Co., Holyoke, Mass.; Frank B. Durfee, Norwich, Conn.; Henry F. Jenks, Pawtucket, R. I; H. B. Winship, (Ludlow M'fg. Co.) New York; J. A. Tilden (Hersey Meter Co.) Boston, Mass.; B. Frank Polsey, (Walworth M'fg. Co.) Boston, Mass.; J. Henry Wells, (Vacuum Oil Co.) Boston, Mass.

After a meeting of the Executive Committee, the President called the meeting to order and the following gentlemen were elected:—

ACTIVE MEMBERS.

F. B. Carroll, Supt. of Construction, New London, Conn.

Lucas Cushing, Boston, Mass.

John R. Freeman, Hydraulic Engineer, Boston, Mass.

John A. Goodwin, Supt., Waterville, Me.

Wm. R. Groce, Rockland, Mass.

Lewis E. Hawes, Constructing Engineer, Dover, N. H.

Frederick W. Wilder, Woodstock, Vt.

Levi C. Wadleigh, Prest., Haverhill, Mass.

Robert C. Bascot, Jr., Supt. Meter Dept., Hoboken, N. J.

Prof. Chas. F. Chandler, New York city.

Wm. Paul Gerhard, Sanitary Engineer, New York.

C. W. Paine, Civil Engineer, Cleveland, Ohio.

ASSOCIATE MEMBER.

James M. Betton, Agent H. R. Worthington, Boston, Mass.

At 1 o'clock the Association sat down to lunch, prayer being offered by Rev. D. N. Beach. After cigars had been lighted, the following papers were read: Construction and Management of Water Works, by Hon. C. W. Kingsley, of Cambridge, Mass.; What is the Safe Ratio of Pumping Capacity to Maximum Consumption? by Wm. B. Sherman, C. E., of Providence, R. I.; Water in Some of its Higher Relations, by Rev. D. N. Beach, of Cambridge, Mass.

After reading of papers, the President called on Mr. Brackett to explain his scheme for the next meeting.

Mr. B. thought that the social character of the meetings ought to be preserved, and proposed that the next meeting should be devoted to short accounts of personal experience in overcoming obstacles, as sometimes the little things were of the most interest. He asked that each member come prepared with a paper of two to five minutes duration.

At the call of the President, about twenty members promised to furnish short papers, and remarks were made on this subject by the President and Messrs. Darling and Coggeshall.

After a vote of thanks to Messrs. Kingsley, Sherman and Beach, for the papers read, the Association adjourned.

ADJOURNED MEETING.

AT YOUNG'S HOTEL, BOSTON, JANUARY 16TH, 1889.

The following members and guests were present:

Solon M. Allis, Supt., Malden, Mass.; Charles H. Baldwin, Boston, Mass.; W. H. Barney, Supt., Milford, Mass.; Everett Barns, Supt., Westerly, R. I.; Wm. R. Billings, Taunton, Mass.; Dexter Brackett, Supt., Boston, Mass.; Robert Grant, Boston Water Board; E. J. Chadbourne, Supt., Holbrook, Mass.; Geo. F. Chace, Supt., Taunton, Mass.; Lucas Cushing, Boston, Mass.; R. C. P. Coggeshall, Supt., New Bedford, Mass.; Edwin Darling, Supt., Pawtucket, R. I.; Nathaniel Dennett, Supt., Somerville, Mass.; W. F. Farnum, Lawrence, Mass.: George E. Evans, C. E., Lowell, Mass.; Desmond FitzGerald, Supt., Boston Water Works, Brookline, Mass.; F. F. Forbes, Supt., Brookline, Mass.; Frank L. Fuller, C. E., Boston, Mass.; Albert S. Glover, Water Registrar, West Newton, Mass.; Mr. Wisnall, Newton Water Board; Three members of Salem Water Board; W. R. Groce, Rockland, Mass.; Richard A. Hale, Hydraulic Engineer, Lawrence, Mass.; Frank E. Hall, Supt., Quincy, Mass.; John L. Harrington, Cambridge, Mass.; William M. Hawes, Water Commissioner, Fall River, Mass.; Horace G. Holden, Supt., Nashua, N. H.; Horatio N. Hyde, Jr., Supt., Newtonville, Mass.; A. W. Inman, Boston, Mass.; Hon. C. W. Kingsley, Cambridge, Mass.; Wilbur F. Learned, A. E., Boston, Mass.; Josiah Oakes, Malden, Mass.; Hiram Nevons, Supt, Cambridge, Mass.; Albert F. Noyes, C. E., West Newton, Mass.; John H. Perkins, Supt., Watertown, Mass.; George J. Ries, Supt., East Weymouth, Mass.; L. Fred. Rice, C. E., Boston, Mass.; Walter H. Richards, Supt., New London, Conn.; A. H. Salisbury, Supt., Lawrence, Mass.; Charles W. S. Seymour, Supt., Hingham, Mass.; J. Herbert Shedd, C. E., Providence, R. I.; Mr. Plunkett, Marlboro, Mass.; George A. Stacy, Supt., Marlboro, Mass.; Frederick P. Stearns, C. E., Boston, Mass.; Lucien A. Taylor, C. E., Boston, Mass.; D. N. Tower, C. E., Cohasset, Mass.; George E. Wild, Boston, Mass.; W. P. Whittemore, Supt., North Attleboro, Mass.; Horace B. Winship, C. E., Norwich, Conn.; George E. Winslow, Supt., Waltham, Mass.; E. R. Jones, Boston, Mass.; E. F. Pierce; E. H. Dockan, Boston, Mass.; Chadwick Lead Works, Boston, Mass.; Chapman Valve Mfg. Co., Indian Orchard, Mass.; J. M. Betton, (H. R. Worthington) Boston, Mass.; Gilchrist & Gorham, Boston, Mass.; Henry F. Jenks, Pawtucket, R. I.; National Meter Co., New York city; Peet Valve Co., Boston, Mass.; Sumner & Goodwin, Boston. Mass.; C. W. Talcott, Woonsocket, R. I.; J. A. Tilden, South Boston, Mass.; Union Water Meter Co., Worcester, Mass.; Walworth Mfg. Co., Boston, Mass.; R. D. Wood & Co., Philadelphia, Pa.; S. A. Welsh.

After the usual lunch the meeting was called to order by the President, who remarked as follows:

The President. I think we are now in good condition to proceed with our business, but before we begin on the regular programme I would like to propose the name of Thomas M. Gale, of Glasgow, Scotland, engineer and superintendent of the Loch Katrine works, as an honorary member of this institution. I have consulted with our friend, Mr. Murdock, of St. John, as to the propriety of so doing,

Mr. Darling. I move you, sir, that the gentleman be elected an honorary member of this Association, as requested by our President. And I would also move that the President then be authorized to communicate with him.

Mr. Jones. I second the motion. If our friend Murdock, of St. John, recommends him I think we can safely take his word for it.

Mr. Gale was then elected unanimously an honorary member of the Association.

The Secretary read a communication from the Boston Society of Civil Engineers extending to the members of the Association a cordial invitation to attend a meeting of the Society to be held this evening. On motion of Mr. Glover the invitation was accepted, and the Secretary was instructed to extend to the Society the thanks of the Association.

The President. The next business in order is the discussion of Mr. Sherman's paper, "What is the Safe Ratio of Pumping Capacity to Maximum Consumption?"

DISCUSSION

BY

WM. R. BILLINGS, Taunton, Mass.

Mr. President:—I am sure you have been misinformed if you think that Mr. Billings has a paper to present to this meeting. I can claim no such honor as that. The junior editor asked me ten days ago if I would discuss the interesting collection of figures and facts that Mr. Sherman put before you quite recently, and although I by no means felt equal to giving the task the treatment it deserved, yet I was anxious to do something to show my continued interest in this Association, and, therefore, the slight effort I make to-day is mainly on that account. I have enjoyed so much here, not only to-day but other days, that I take pleasure in doing even what little it is possible for me to do.

I have read Mr. Sherman's paper with a great deal of interest, and I would say, to begin with, that I agree quite heartily with his final statement that no fixed formula could be given which should answer the question "what should

be the ratio between the ordinary capacity of a pump and the maximum demand which should be made upon it," or would be likely to be made upon it. The question at present seems to be one which must be treated by getting together all the facts and figures and conditions that can be had, and arranging them as he has done so well in his paper. Even after these facts are collected I doubt if it will be found practicable to make any rule which shall cover any considerable number of cases. Because in the slight time which I have given to the question, the cases appear to be so diverse, and often made up of so many contradictory conditions, that one can do but little more than study each case and see what the conditions are.

For instance, it seems to me that it is not simply a question of how much water is used ordinarily and how much will be the maximum demand. It occurs to me that there are other conditions entering into the problem. It would be safer, for example, to run closer to the line, to have the ordinary capacity much nearer the maximum demand, in some cities than in others. For instance, would it not make a difference whether the town were a flat or a hilly town, because that would influence the rapidity with which the fire department could reach the scene of action, and time is of the first importance in such matters? Would it not make a difference whether the town were thickly or sparsely inhabited? Would it not make a difference whether the buildings were low or high? Would it not make a difference whether they were built of stone or of wood, whether the streets were in general broad and straight or narrow and crooked? Would it not make a difference whether there was a well-organized fire department with a thoroughly skilful and efficient chief engineer? Would it not make a difference whether there was a good system of giving the alarm when a fire was first discovered? Would it not make a difference whether there is a building law, or, more than that, whether the building law is enforced? Further than that, it would make a difference, I think, as to what the probable character of the town would be as regards the waste of water. Some cities and towns are much more wasteful than others, and the waste increases in a greater ratio in some places than in others—fast enough in all places, goodness knows, but still there is a difference. It would make a difference whether metres were in use or not, and whether there was a good system of inspection which might to some extent take the place of metres; whether it was a manufacturing town like Fall River, or a suburban city like Newton; whether the town had in it many rows of tinder-box tenement houses, occupied by tenants careless of the risk from fire. Those items, to speak nothing of others which might occur to you, it seems to me, do enter into the decision of the question. And they enter into it, as it appears to me, because, as Mr. Crafts so clearly points out, and as Mr. Sherman quoted, it is essential to determine what is reasonable safety and where the line is.

Perhaps the largest number of people who would be interested in a discussion of this question would be those who live in small towns. The larger cities of the country are well supplied with water, and the question of what their ratio should be, while an important one, is perhaps not a new one for

them to settle. But in the case of small towns and cities which are establishing a public water supply, it is quite important that they should arrive at a just and safe decision to begin with, for it is always well to begin right. Now, I am the last man in the world to advocate a picayune policy. I despise it above all things. But at the risk of getting myself put a little bit in that category, I am going for the present to incline a little in a direction which engineers are not often fond of following, and that is towards running a little closer to the margin than is commonly thought wise. Some reasons have occurred to me why a small place, can get along with a smaller amount of pumping capacity than is often thought wise, and these I will proceed to give to you.

The broad, comprehensive planning which should enter into any system of water supply or drainage for a large city must be followed, it seems to me, with a good deal of care and judgment in planning for a small town. If the young engineer in his enthusiasm should, for instance, follow the suggestions given by Mr. Fanning in his book, on the page which Mr. Sherman quotes here, in which he adds 17 per cent. for one thing, and 10 per cent. for another, and so on, I think in nine cases out of ten he would produce a plan which would be excessive in cost to the town and unreasonable. I do not wish to be understood as criticising Mr. Fanning's work, because that speaks for itself, but I am applying it to the particular case I have in mind of a small town. There are so many conditions to be thought of, that oftentimes the men who are managing the town's business are, after all, the safer ones to make the final decision as to how close to the line of reasonable safety they will run. The engineer can give them the material on which to base their decision, he can marshal the figures before them, tell them what has been done in other places, and what may be done, and what the chances are; but the men who know thoroughly the condition of the town, its resources, present and future, are the best ones to make the final decision as to how close to the line it will be safe for them to go. It really seems to me that they are safer men to make that decision than the engineer, who would be influenced by his desire make things safe and sure and strong, with a large margin.

And, incidentally, I may remark that I am inclined to think, from the limited experience I had in Taunton, at any rate, that the quantity of water which is commonly allowed per minute for a fire stream, in smaller places is almost too large, if you want to figure closely. Two hundred gallons a minute per stream makes, so far as I can judge, a very generous one; and 150 gallons a minute will give a stream which, for a small place with low buildings, buildings well separated, is ample. I base that statement on two facts. One is that I tested by the use of a metre some fire streams at one time, and found just how large a stream, 150 gallons a minute appeared to be, and another is that in several fires we have had, we have been able, by following our pumping records, to know how large the streams actually were. And in two of the largest fires we have had in Taunton since the works were started, through the courtesy of my successor, Mr. Chase, I am able to say that on July 8, 1878, there were six streams thrown for five hours steadily, a pretty sizeable fire, and the average size of those streams was only about 130

gallons a minute, and there was no complaint of scarcity of water at all, there was plenty of it. And at another fire, which occurred in September, 1886, where eight streams were playing for two hours and a half, the average quantity of water per minute was only 150 gallons. So that in small towns and cities, where it is desirable to figure very close, it seems to me that 200 gallons a minute is ample, and may be shaded a little if necessary. And, more than that, more than 200 gallons a minute, which is sometimes allowed, cannot be played in one stream, unless you concentrate two or three lines of hose into a Siamese connection, because a long line of hose ordinarily will not deliver more than 200 gallons per minute, and hardly that sometimes. Now, stop and think, in the case of a small town, how slight the chances really are of having a fire which will require the concentration of ten streams at once. Take it in any of the smaller towns and just try to pick out a place where it is at all probable that ten streams at once will be required; and if you consider it in a moment of calmness, when you are not at all anxious about anything, you will find that the number of such places is very small in an ordinary New England town. I am not speaking, of course, of a thickly settled manufacturing town. So there again it occurs to me that sometimes too large an allowance is made, and that too great a difference is called for by the engineer between the ordinary pumping capacity, and the maximum. I merely throw out these suggestions on this point, and will let the matter rest there, so far as that is concerned.

Only one point more I want to make. I read, of course, while in the water department at Taunton, every report that came into the office, and I was often impressed with the constant cry that is put in nearly every report, by the superintendent or engineer, that more pumping capacity must be had, and it was always accompanied with an expression of regret, and sometimes of impatience, that the City Council or the Town Council had refused to listen to the demand, and had persistently, not only ignored it, but seemed to think that the water works officials were making an unreasonable request, and so on. I may mention, for instance, the report from the city of Atlanta, to quote from Mr. Sherman's paper. The superintendent there speaks of a time when the pumps were running at the rate of 1,300,000 a day, and he says the pumps were calculated to do only 2,000,000, all four of them, and he thinks he was running the pumps at an unusual rate of speed, and that the risk was too great. Now, when you come to figure a little more closely, you find the figures he gives, 1,300,000 gallons per day, with one pump disabled and three running, show that the pumps were only running at their rated capacity. Now, why should they not run at their rated capacity if necessary? What are they good for if they cannot, and what need is there of becoming very much disturbed and alarmed, because the time comes when you have got to crowd your pumps up to their capacity? What are they there for if you can't do that? It does not occur every week or every day as a matter of fact, and it makes the superintendent a little nervous to see it done; but I imagine that the members of the town council say, "Why shouldn't it be done? The pumps are for that purpose, and let him run them as hard as they will run, and they are not good for much if they can't be run hat way once in a while."

Then following right on we come to this statement from Dayton. The superintendent says: "If any accident should occur to the new engine while operating in time of fire we would be dependent on the old engines." And then he goes on to cite a case where that very thing happened, and he shows that he makes a misstatement when he says, as he does, "Should the fire be of any magnitude we would be unable to supply the demand for water," for in the very next paragraph he gives an instance where the new pump was disabled, and they did have a fire of great magnitude, but they "got there just the same," and supplied the water, (Laughter.) How did they do it? The new machinery was not wholly disabled, it was only partly disabled, and, of course, like a vigorous man, he went to work and used what was left of it, helped out with his old machinery and got out of the scrape. And he will do so in ninety-nine cases out of one hundred, and it is because town councils and city councils know that, it is because they know that he will do so, and know that the risk is so small it is not worth talking about, that they do turn a deaf ear to the cry for more machinery and more power. They get the idea that water works men are a lot of Oliver Twists, always wanting more, always crying wolf, and they get tired of it.

Now, it appears to me it would be wiser on the part of water works men—I wish I could say on the part of us, but I cannot, because I am not one of you any longer,—to make your calls and statements less vehement, less hysterical, so to speak. Put the figures right down where they are and say, there are certain chances; if this machine breaks it will cripple us, we will have to do thus and so; we will try to do it, but here are the chances, gentlemen of the council, you can measure them as well as we can, and now if you wish to take them we will say no more about it but do our best to get along. The constant cry for something more, that the thing is going to the demnition bowwows if you don't get things into shape, is likely to lose its force after awhile. The city council have to meet not only calls from the water department, but there are calls from many directions. The highway men say the highways must be kept in condition, new streets must be laid out, bridges maintained, and there are school houses to be built and kept in order, and all these demands are constantly being made upon the city council. Now it is not strange that the city councilmen sometimes say, "Why these water works fellows are telling us all the time that they must have something more or things will go to smash, but still we haven't burnt up yet and nothing has happened to us." And you will notice that in the very cases reported in Mr. Sherman's paper, in Pawtucket, in Dayton and in Atlanta, they ran very close, but they got there every time and they didn't have any serious trouble. The history of the past makes councils, perhaps, a little bit readier to run closer to the margin than some of us are willing to. (Applause.)

DISCUSSION

BY

DEXTER BRACKETT, Superintendent, Boston, Mass.

Mr. President and Gentlemen:—I think Mr. Sherman has very well covered the subject, and given us a very valuable and instructive paper. I do not know that I quite agree with Mr. Billings in all his points. I think there is not much need of caution as regards the size of the pumping plant. As he himself said, the general cry is for an increase, and I myself do not recall any cases where the original works have been complained of as being too large, or where complaint has been made that the machinery put in was too large. There may be cases, but I never have happened to hear of them. It seems to me that the question which arises in considering the subject is, perhaps, not so much the ratio between the pumping capacity and the maximum consumption, as it is the ratio between the pumping capacity and the daily average consumption. That is, the daily average consumption is the figure which is generally used in speaking of water supplies; and from that the maximum in different cities may vary very largely. The consumption of a city or town is generally given in daily average for a year. Taking for example a town using one million gallons per day, it is found by experience in Boston, at any rate, and I think it will follow in some other places, if not in all, the extreme consumption during either hot or cold weather will be double the daily average.

Then, furthermore, the hourly consumption during the day, judging from experiments I have made, will be at least 50 per cent. in increase of the daily average, that is, 50 per cent. in increase of the original yearly average, and sometimes more than that, although, in the case of extreme cold, the hourly average during the night is very often as large as it is during the day time. Well, now, basing our estimate upon these figures, with a city or town supplied without a reservoir, with either a direct pumping plant or with a standpipe, we should require two and one-half times the daily average consumption for a pumping capacity; and in order to make the works absolutely safe, I suppose it would be necessary to duplicate that machinery, which would give us five million gallons pumping capacity for a daily average of a million gallons. That, however, I should say might be, as Mr. Billings has said, excessive, or might be modified to favor particular cases. If the city government saw fit to run the risk and work on half of that, why well and good.

Of course where water is pumped to a reservoir the pumping capacity can be safely reduced so as to eliminate both the cold weather consumption, or a part of it, and all of the increase of hourly consumption. I should say that if the pumping capacity was three times the daily average, it would be perfectly safe, at any rate in works supplied from a reservoir.

As to the question of water required for fire service, I should agree with Mr. Billings that 200 gallons per minute for a fire stream is an ample supply. Although we very often speak of a fire where there were ten, or fifteen or twenty

streams in use, it will be found by careful examination that that whole number was not in use at the same time. As President Nevons suggests, it is "hold on one," or the hose has burst; and there are very few instances where there is not some interruption to some of the lines, and for that reason the quantity may, as Mr. Billings has stated, drop down to 130 or 150 gallons. And even if they are in use, it is very seldom that they use more than 200 gallons per minute per stream. Of course, in small works, the quantity that would be necessary for fire purposes will enter into the question of the capacity of the pumps; but when you get a pumping capacity of five or six millions gallons, that is generally large enough to provide for any fire which is likely to occur.

DISCUSSION

BY

FRANK L. FULLER, C. E., Boston, Mass.

Mr. President, and Members of the Association:—I have been interested in the remarks of Mr. Billings and also of Mr. Brackett, in regard to this question of the capacity of the pumping machinery as compared with the maximum consumption. My connection has been mainly with small works, and it seems to me that there is, perhaps, a point of difference which might be brought into account. It is very frequently the case, I think, that in small works the superintendent attends to the pumping himself; and it seems to me that it is an advantage to so plan the machinery that he can do his pumping in two or three days, or parts of two or three days in the week. That leaves him time to attend to his general duties, and does not require him to be at the pumping station all the time. For instance, if he has a million and a half pump he will pump somewhere about 60,000 gallons an hour, and if the consumption is, we will say, 160,000 gallons per day, that would allow him to do his pumping in about five hours of every other day, if he pumped three times a week, pumping five hours, say from eight in the morning until one in the afternoon, something like that. As the consumption increased he would have to pump until two o'clock or three o'clock. That gives him one whole day to attend to his duties in connection with the works.

This practically would give a larger ratio of pumping capacity than would be required in a larger town or city, where an engineer was engaged regularly to do the pumping. There, of course, if he pumped ten hours a day, that would occupy his whole time and that for a fireman. But in these smaller works it seems to me it is very wise to plan the machinery large enough so that the pumping can be done in a less amount of time.

In Mr. Sherman's paper he quotes from Mr. Crafts as saying that in a town which required at the present time 300,000 gallons per day, the best engine to adopt, the best pumping machinery to adopt, would be that of about 1,000,000 capacity. Well now, it seems to me that I should put it at least a million

and a half, if not two million gallons, for the reasons that I have stated. If he has a reservoir of a million or a million and a half capacity, which it seems to me is large enough for ordinary small towns, if he keeps the reservoir filled to the high water mark, as it seems to me should be done, there is an ample reserve for any case of fire that is likely to occur. And in planning works for a town of five, or six or seven thousand inhabitants, it seems to me I should adopt a million and a half gallon pump, and a reservoir of a million or a million and a half gallons capacity. The pumping machinery and the pumping station, ought to be so planned that in the course of a few years another pump of about the same capacity can be added. Then the machinery will be in duplicate. It seems to me that it is wise to put in two boilers to begin with, and then it will not require another boiler when the second pump is put in.

In regard to the question of the amount of water used at a fire, I took the pains to try to inform myself of the amount of water that was used at the recent fire in Marblehead. The superintendent of the Marblehead Water Company, which is located in Swampscott, wrote me that for sixteen hours, beginning almost at the time the fire broke out, he pumped at the rate of 50,000 gallons per hour, and that for the next twenty hours he pumped at the rate of 40,000 gallons per hour. I cannot tell you exactly as to the number of streams. I have written to the Chief Engineer of the Marblehead Fire Department, Mr. Atkins, but have not received an answer from him. I judge from what I have read that there were four or five steamers at work a part of the time. I presume, however, as Mr. Brackett has suggested, that those steamers were not constantly at work, I know that one of the steamers belonging to the town of Marblehead was disabled, which, of course, left them only one steamer, and I think they had two hand engines. There was one steamer from Peabody; one from Salem, also, I think. There may be those here who can tell us more exactly, but I think they had four or five steamers and these two hand engines. The pipe which leads from Swampscott to Marblehead is partly 8-inch and partly 10-inch. As nearly as I could judge from the map there were somewhere about three miles of 8-inch pipe, and nearly two miles of 10-inch pipe. It does not seem to me that engineer at Swampscott could have pumped 50,000 gallons per hour through this length of pipe, but those are the figures which he has given me.

As to the amount of water, whether they would have used more water if they had had it, I can't say. The amount of water that they received from Swampscott was no more than would supply the steamers which were at work, because I am told that in one case one of the hydrants became so hot that they had to leave it, and the hydrant was left without shutting it, but no water came from it, and, on the contrary, they claim that air was drawn into the pipes through this open hydrant. (Laughter.) If they had had more water and more steamers, perhaps the fire could have been stopped sooner; although, of course, it must be remembered that the character of the buildings which were destroyed was conducive to their being quickly consumed. They were, as you know, wooden shoe factories, with nothing but

board partitions, very dry and more or less saturated with oil, and therefore it would probably have been very difficult, even with an adequate supply of water, to extinguish this fire.

The pressure that was maintained at the pumping station at Swampscott was sixty pounds, according to the report of the Superintendent of the Works. They pumped into a small stand-pipe, about 110 feet high and twenty-two feet in diameter, if I remember correctly. Their pipe as far as the Marblehead line is a cement pipe, and the Superintendent told me he did not dare to shut off the stand-pipe and pump direct, because he was afraid of bursting the pipe. If they had had a supply nearer at hand, or a stand-pipe in their own village, it would have given them of course a better supply of water. I think this is a very interesting point, and although I think, as Mr. Billings has said, that it is unwise to plan too largely, yet there may be some considerations outside of the mere matter of cost which would lead the town, for the convenience of operating the works, to put in machinery a little larger than would be required just at the present time. Every town is bound to grow, and I think, as Mr. Brackett said, that there are not a great many towns that after ten or twelve years think they planned too large; they are more apt to be of the opinion that they might have built a little larger to advantage. (Applause.)

DISCUSSION

BY

A. F. Noyes, C. E., of Newton, Mass.

Mr. President:—I don't know as I can add anything of importance to what has been said and to what is covered by Mr. Sherman's paper. Of course we are all apt, at least individually, to look at these matters in connection with the works we have been engaged upon. For instance, Mr. Brackett who has very large works, where the consumption is enormous as compared with many of our works, and Mr. Fuller, whose connection, as he states, has been with smaller works, where the Superintendent has generally taken charge of the pumping himself, naturally look at the matter from different standpoints. And I think we must, as Mr. Sherman states, take each individual case by itself, and that we cannot draw any specific conclusions covering a considerable number of works. From my observations, however, I think where a permanent man is employed to do the pumping, it is well that the pumping capacity should not be too large. The particular stress should be put upon the duplicating of the plant, so that if necessary both pumps can be run at the same time, but the single pump should be run every day in the week. It tends to promote good feeling to have the engineer constantly employed, it keeps his mind active, and prevents disturbances that are likely to arise in the works but for that continued employment.

In reference to the quantity of water required for fire purposes, that varies with the compactness of different places and their character. As Mr. Billings correctly concludes, Newton, being a residential district, fires of very considerable magnitude are not likely to occur there, and it seems to me that from six to seven streams is the maximum which we might reasonably be called upon to expect to provide for at any one time; and that would give a maximum amount of about 60,000 gallons per hour.

I have seen by reference to a paper prepared by a Mr. Russell of the St. Louis Department, that his conclusions from the results of very exhaustive experiments made there, agree very closely with those of Mr. Sherman. He concludes that 5,000 gallons per minute in places where there are large buildings close together would be a maximum amount, and for residential districts 1000 gallons per minute. That agrees with the conclusions of the gentlemen who have spoken here, and also the statements set forth in the paper. I do not know of anything more that I can add to the discussion.

DISCUSSION

BY

J. Herbert Shedd, C. E., Providence, R. I.

The suggestive paper of Mr. Sherman on the ratio of pumping capacity to maximum consumption, treats of a matter which is of great moment in the design of water works construction or enlargement.

A supply of water for fire purposes is usually the most important element of the cost of a water works distribution, and, as a rule, it may be said that half the cost of a water works system is made necessary by providing a proper fire service and that all other sources of revenue combined may be provided for by the other half of the cost,

The question, then, of what, under given circumstances, is a suitable supply for fire purposes becomes very important.

The promptness with which water can be applied is the most essential limiting agent in the quantity required. And, as affecting this, the closeness of the buildings to each other, their height, their construction, their contents and the means of outside access are controlling conditions.

Automatic application of water, acting by the heat of the fire itself, seems to be the best limiting agent of the quantity required that has yet been discovered.

Experience from about four hundred fires leads to the fair expectation that premises well protected by so good an appliance as the Automatic Sprinkler may have a fire, in very inflammable material, extinguished by the application of three hundred and fifty to seven hundred and fifty gallons of water. No effort has been made to record the number of sprinklers which open at the various fires, but an examination shows that seventy-five parties have so reported and the following list gives the result :—

38	fires	where	1	sprinkler	opened,	38
17	"	"	2	"	"	34
7	"	"	3	"	"	21
3	"	"	4	"	"	12
2	"	"	5	"	"	10
4	"	"	6	"	"	24
2	"	"	7	"	"	14
2	"	"	10	"	"	20
75	fires in all, using					173 sprinklers.

These sprinklers are set under pressures varying from 5 lbs. to 80 lbs. per square inch and discharge at those pressures from 1.25 to 4.97 cubic feet per minute each. Much of the property protected by these sprinklers, like picker rooms, carding rooms, mule-spinning rooms, etc., will, when fired, flash into flame with almost explosive effect, and yet in a large portion of fires the owners have made no claim upon Insurance Companies for loss. The losses which occur average only about $150 per fire, while losses on similar risks, not having sprinklers, have averaged over $7000 per fire. I mention these things only to emphasize the value of the prompt application of water in lessening the amount required.

If this result could be the universal experience, no especial notice would need to be taken of the "fire supply." But this is the limit in one direction; the limit in the other is the quantity required to extinguish such conflagrations as the great fire in Chicago and that in Boston.

Considering the matter broadly, and as affecting an entire water supply, there seems to be a relation between the population to be protected and the number of streams required to give that protection. This is the result of my experience and I think it may reasonably appear to be so, upon reflection, independently of experience, when the conditions affecting the promptness with which water can be applied are considered as above noted.

As a general guide to be modified by the known conditions and the probable future changes for each town, I suggest the use of the following formula :—

Number of streams required equals the square root of the population, multiplied by .005. The standard stream to be that which will deliver 200 gallons of water per minute. The population to be that future estimated population for which it is deemed best to construct the works. Of course the quantity thus estimated is to be added to the quantity supposed to be required for other uses to obtain the total maximum capacity of the works to deliver water.

I have been in the habit of proportioning the distribution pipes for a population of about eight thousand, so that six fire streams can be thrown from any point within a line which would, under the usual practice, bound the "fire district." This has been practically satisfactory. The rule would give six streams to a population of 7,200.

The city of Bridgeport, Conn., has recently had a careful examination by a good committee into the whole question of a supply of water for fire purposes,

and the conclusion arrived at was that thirteen streams ought to be provided for. The population is taken at 40,000. The rule would give fourteen streams.

The case of Fall River, cited by Mr. Sherman, is interesting, and probably the demand for water there would be greater than in ordinary towns. The greatest amount of water required at any fire was on Dec. 8th, 1874, at the rate of 155,388 gallons per hour, which would be delivered by thirteen standard streams. Taking the population at 45,000, in 1874, the rule would give fifteen streams. At the fire of Nov. 17, 1877, which was the most disastrous that had occurred, entailing a loss of $450,000, eleven streams were used and they were nearly up to the standard in quantity of water discharged.

In the city of Worcester the greatest number of streams ever used at a fire is understood to be eighteen. Taking the population at 73,000 the rule would give nineteen.

The fire in Providence, September, 1877, was very extraordinary. I understand that the Fire Department did not possess nozzles enough to use twenty-five streams, but depended on other towns for a part of them. In the fire of February, 1888, a less number of streams were used—I have forgotten the exact number (and for the time my notes are not available) though I took special pains at the time to learn what were used—probably twenty-two standard streams would cover the quantity, equal to 264,000 gallons per hour. Taking the population at 120,000 the rule would give twenty-four and a half streams.

In the case cited by Mr. Sherman, of Norfolk, Virginia, with a population of 58,564, the amount of water used would be delivered by about five standard streams, while the rule would give seventeen streams. But this was a record of average use and for the present purpose we wish, not the average but the maximum demand, for which it will be profitable to spend money to provide. Most fires, in any case, are put out with two to four streams, but there should be a good water supply for use in case the fire "gets away" from the firemen.

It thus appears that up to a population of 120,000 the rule accords well with good practice. It may be thought that were the curve pushed forward to a population of a million the seventy-one streams required would be excessive, but it is not difficult to conceive that a fire started in the dense dry-goods district of New York, with the firemen hindered as may readily be imagined, would require seventy-one streams to confine it to the block in which it started.

All this question of quantity required for a fire supply affects the pumping capacity only when direct pumping is to be practiced, or pumping into a small standpipe. When a reservoir, or reservoirs are used, of sufficient capacity near the population, the pumping capacity may be limited to keeping them supplied through all the contingencies of use and accident.

The President. There is an opportunity now for any one who wishes to question the gentlemen who have discussed this paper.

Mr. Noyes. One question occurred to me in listening to the remarks of Mr. Shedd. I would like to ask him if, in obtaining the population he took any unit of area. For instance, it occurs to me that there are some places that have compact centres with large outlying districts, and there are other places in which the population is pretty evenly distributed over the whole area, and I would like to ask what unit, if any, of areas he used?

Mr. Shedd. The population should be taken, I think, in the compact portion of the town which would be ordinarily included within the lines of a fire district, as they are ordinarily made in towns supplied with water for fire purposes. Of course, in determining what you would allow for fire purposes you would also take into consideration the population which is to be expected in the future before you make a radical remodeling of the works. Naturally a line like that must be only an approximation. This is only given as a general guide to be modified in each case by its conditions; and generally, for such a purpose as that, the population has a relation to the density which is fairly useful in that formula. In comparing with the number of streams which have been actually used in the greatest fires, I have taken the population which existed at the time of the fire, but of course in planning the works you would provide for a greater number of streams. For instance, the city of Providence has a capacity to discharge, without increasing the normal velocity in the pipes, over thirty streams on to a fire; and by increasing the velocity slightly and within reasonable limits, you could run up 50 or more per cent. of the number of streams. The rule would be in proportion to the population in the denser portion of the town.

The President. If no one else wishes to ask questions, I will call on Mr. Sherman.

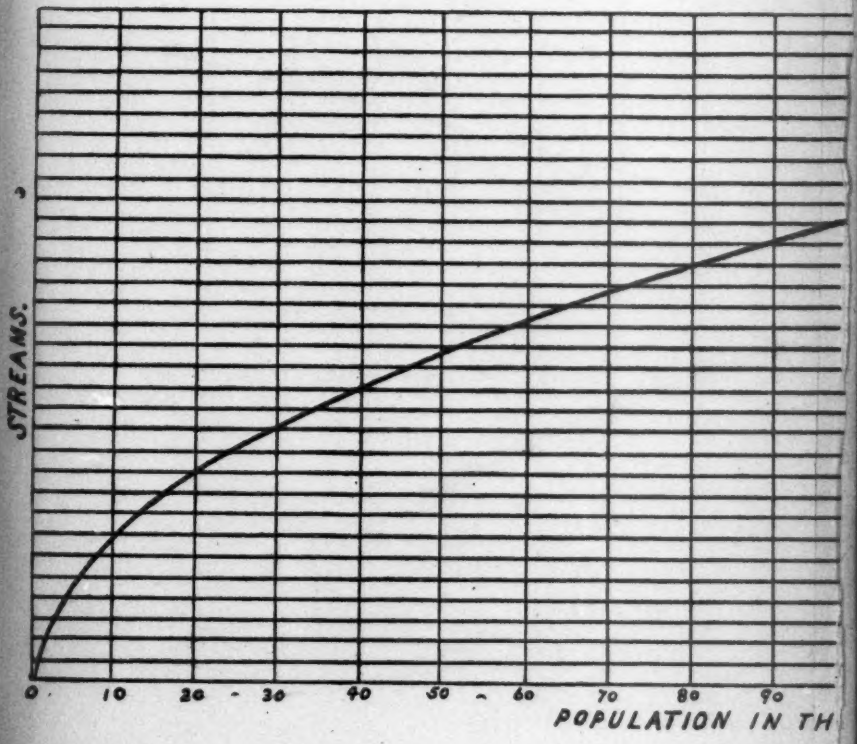
DISCUSSION

BY

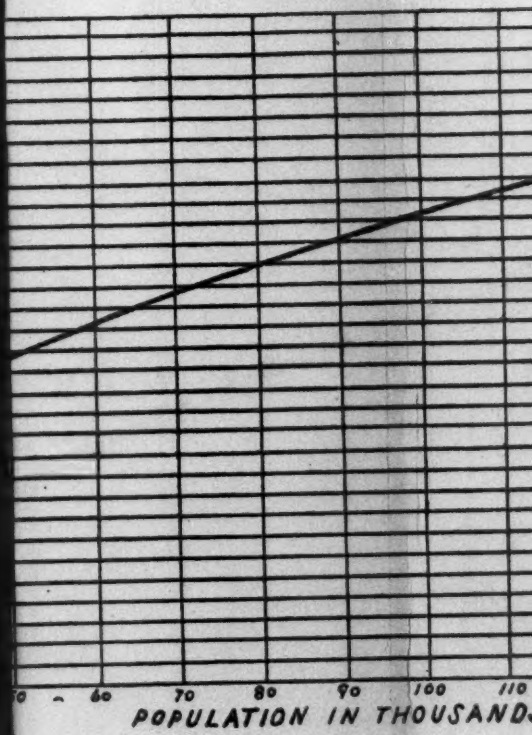
Wm. B. Sherman, Providence, R. I.

Mr. President:—I have enjoyed the discussion of my paper very much, and don't know that I can add anything to it. I would like to make one correction as to what Mr. Billings stated with regard to the case at Atlanta, speaking of the fact that the pumps were only up to their ra ted capacity, for I think he was in error upon that. It is stated that the four pumps had a capacity of 2,000,000 and the average consumption for the month of August was 1,300,000 per day. You must bear in mind that this system is direct pumping. Now then, three quarters, one pump being disabled, would be 1,500,000. This 1,300,000 was not what the rate was at the time they were pumping. It exceeded that. That was the total for the month of August. The report goes on to say, "When it is known that this consumption was supplied with three pumps and that the fourth were only calculated for a supply of 2,000,000 in

MAXIMUM NUMBER of FIRE STRE
required for each 1000 Population.

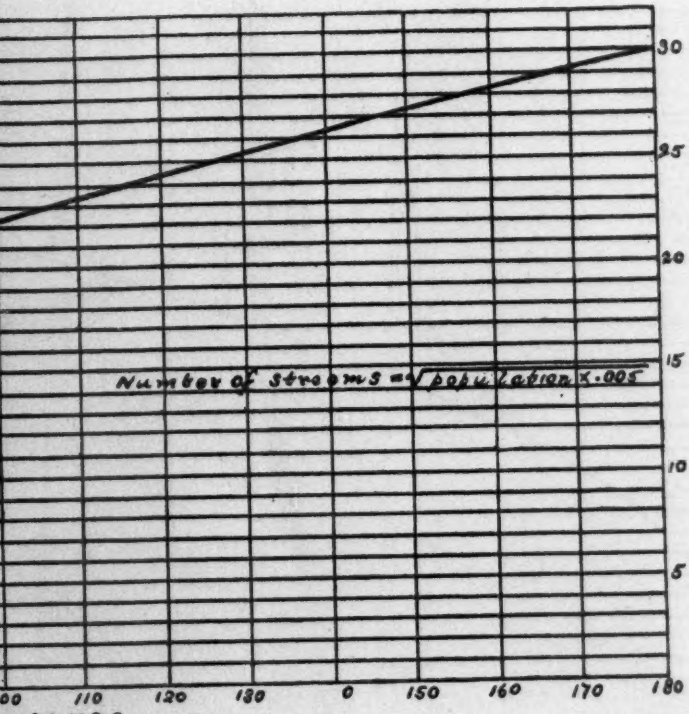


ER of FIRE STREAMS
000 Population.



AMS of 200 Gallons per minute

J. HERBERT SHEDD, C. E.



twenty-four hours, and that for about nine hours of the twenty-four comparatively little water is taken, you will realize the speed at which it was necessary to run the machinery." Therefore there can be no question but that these three pumps were run far in excess of what the builders intended them to do.

Speaking of the unit in the ratio, of course that depends really on the system, whether a direct or a reservoir system. For a reservoir system I should think the unit should be the average of several days of maximum consumption; that is to say, suppose a works had a pumping capacity of 2,000,000, a maximum consumption of 1,000,000 per day, and a reservoir capacity of 10,000,000, supposed to be kept intact, that is, full. Now they have in that ten days' supply, which would allow that length of time to make repairs to the machinery when disabled, drawing on the reservoir alone. So I think for a reservoir, its capacity should be, to a certain extent, counted as part of the pumping capacity. But when it comes to direct pumping, the unit is the maximum demand for a very limited time, and is the quantity that would be used by the greatest number of fire streams available. In this case, as the pump is the only source of supply, its capacity should bear a much greater ratio to the maximum consumption than where there is a reservoir. In a case of conflagration the machinery has got to meet that demand, so that the cases vary according to the system.

Mr. Brackett says he knows of no case where the works were built more extensive than were perhaps needed. At the risk of being a little aggressive, I would like to ask Mr. Noyes with regard to the city of Newton. Those works were built in 1875, and a 5,000,000 pump was put in at that time. The report for last year, that is twelve years after, gives as the maximum daily consumption a million and a half gallons. It seems to me that that pump could have been a little smaller at the start. (Laughter.) I would like to ask Mr. Noyes what he thinks of it.

Mr. Noyes. In answer to Mr. Sherman, I would say I think a man can draw his conclusions without the aid of any positive remarks. (Laughter.) The capacity of the filtering basin from which the pump is supposed to be supplied is about eleven or twelve hundred thousand gallons as a maximum. It has a storage, when not draughted upon to its full filtering capacity, of between four and five million gallons. The results are that with an average consumption during a large portion of the time of a little over 500,000 gallons, and during a considerable portion of the time the works have been built, of less than 500,000 gallons a day, the pumps had not been operated more than two days in the week. They are now operated nine hours three or four days in the week. In the summer time, when we are draughting upon the filter basin to its full capacity, they are run very slowly some four or five days in the week, to the extent of 1,100,000 gallons, which, you see, is but a little over half their capacity. It has been felt that it would have been better or more economical to have put in either smaller pumps or to have duplicated them; that is, put in two smaller pumps, and that more efficient results would possibly have been attained.

REMARKS OF MEMBERS.

Mr. Darling. I desire to say one word. I was very glad to hear my friend Shedd allude to the sprinkling service. That was a factor which my friend Billings forgot to take into consideration in enumerating the different things that were dependent upon water works. That factor to-day has got to be quite a large one wherever water works are introduced. You will find wherever you introduce them that the large manufacturing establishments will take the benefit, or take the liberty, of attaching sprinklers, so that factor is getting to be a large one, especially in manufacturing towns.

Now my friend, Mr. Billings, says that he believes the City Councils or the Town Councils are the best judges finally of the size and magnitude of the water works that should be put in. I do not quite agree with him there. I think that the parties in interest, that is, the parties that are supposed to know the wants of a city or town, are better fitted to indicate what is desired. I admit that the City Council or the Town Council, perhaps, understand the financial departments of cities and towns as well as any one, but I claim this, that there is but one department in any city or town which is paramount to the water works, and that is the Educational Department. That comes first, in my opinion, and next to it is the Water Works. And I believe it is poor policy for any City Council or Town Council to cause works to be put in, simply because they come at a little lower price, which are not equal to the demands of the city or town. I believe it is poor policy indeed for them to do that kind of work; and I think that the Board of Water Commissioners are the best judges of the situation.

Mr. Billings. Mr. President, I think my friend on my left (Mr. Darling) has misunderstood my position slightly. I trust the stenographer got my remarks a little more exactly, because I should dislike to have them go into print in just that shape. What I intended to say on the point of making the final decision, was not that the Town Council was the proper body to decide what the town ought to have in the way of water works. I distinctly tried to avoid that statement. But I did say that I thought it often happens that the Town Council, or members representing it, are the best persons to decide what is the line of reasonable safety; that they can judge, perhaps, better than the designing engineer, how near to the line of reasonable safety they, as a town, can afford to run. Because to them it is not an engineering problem; it is an economic problem which involves their own resources as a town present and prospective, and which involves all the other means they have at hand for extinguishing fires. And I do not think that a point has yet been made against that position.

Mr. Hawes. I don't believe the Town Council or City Council know much of anything about it. (Laughter.) In the first place, they don't give any attention to it. In the second place, they are changing every year and they want to be there several years before they get interested enough to make a study of it so they can know about it, while the water boards and the water men are continually making a study of it. I will even go still further than that, and will say as to the capacity of the works, that I think when a town or

city puts in water works, and agrees to furnish a corporation or individuals with water to put out fires, the capacity ought to far exceed what is thought to be really needed. Owners of property depend upon it, the insurance companies reduce their rates because of it, and as I told our government last year, when I wanted to put down a bigger main in a certain portion of our city, where our factories were increasing, and we had shown we had lost two large factories, I believe that in a court of justice the insurance company and the manufacturers who had been gulled by the assurance that they were protected against fire, could make the city pay for the loss and damage. That will go further than Mr. Billings' statement.

The President. Is there anything more to be said on Mr. Sherman's paper?

Mr. Billings. Pardon me, Mr. President, if I throw one more chip on to this pile.

Mr. Hawes. Put some kerosene on it. (Laughter.)

Mr. Billings. I will cheerfully admit the criticism which Mr. Hawes makes as to the entire inefficiency oftentimes of the Town Council to decide upon such questions. But the point which I wish to make is that a man engaged in designing a system of water works as an engineer, or a man interested in a project for water works as a commissioner, becomes to a certain extent an attorney; he is an interested party, he has one object before him, and that alone, and that is to put in the best system he can and do the best he can as an officer and as a manager of this new scheme. Now, in any government, there ought to be some men who, though they have not that knowledge of the details of the scheme which the commissioners or the engineers have, ought nevertheless by reason of their position, to be expected to take a little broader outlook over the whole town's interest. If it happens, unfortunately, that the Town Council is made up, as it often is, of men who are only in office for a little time, as Mr. Hawes suggests, so much the worse for the town. But what I am thinking of is a case in which there are men in the Town Council, or in some position of trust, who can look at the matter broadly and intelligently, and I say that if there are such men—I know it often happens there are not—but if there are, then in the very nature of the case they are better fitted, perhaps, to arrive at a broad and just decision on all the merits of the case than an interested party who would look at it from one side as an attorney.

Mr. Hawes. I would like to say a word with regard to the music. I think we have all found it is a great addition to our meetings here, especially those of us who have music in our souls, and if there is any man here who hasn't, he wouldn't dare to own up to it anyhow. Of course I know this has been attended by some expense, but I hope it will be continued, and I move that it be, and if any expense is incurred that our treasurer be authorized to pay the bills.

Mr. Darling. I fully endorse what my friend from Fall River says. I think it is a benefit, and that it produces good results. I like to hear music as well as any man, and I have no doubt by the looks of these faces around here that we all have appreciated it. I heartily second the motion and hope it will be adopted unanimously.

(The motion was adopted.)

After the above discussion, remarks on personal experiences were made as follows:

REMARKS ON METER TESTS.

BY

L. Fred Rice, C. E., Boston, Mass.

Mr. President and Gentlemen:—About a week ago or a little more I received the December number of the Journal of the Association, in which was a report of a paper which I read, or intended to have read, at the meeting in Providence, which paper was a sort of off-hand re-hash of another paper upon the general subject of testing meters, which I had previously read before the Boston Society of Civil Engineers. But by a mishap that Providence paper was not published in the next succeeding number of the Journal, the report of it having been mislaid; and it did not appear until this December number. In looking over that, I find that two or three gentlemen have very kindly made some comments upon that paper and upon the report upon which it was based, and a few words occur to me which I would like to say in reference to those comments. Since receiving this number of the Journal I have been unable to prepare anything in writing on account of illness on my own part; but I have simply made a few marginal notes, which I hope will suggest what I have to say, and will excuse the informal nature of it.

I see in the first article, which is by Mr. Howland, that he has done me the honor to read somewhat carefully the original report, and therefore has seen the work which the commission laid out for itself, which was quite different from the general appreciation of it. We were appointed to test such water metres as might be brought before us, and to make a report upon such tests. We were not bound to make any comparative test, or to make any comparisons whatever between the various meters which were brought before us; and in order that we might best carry out our work we thought that we would endeavor to examine each meter by itself and report what we found in regard to that, comparing it with no other meter, but simply with absolute perfection; noting its variations from perfection and leaving to the general public, or to whomsoever the report should reach, to draw their own conclusions from the data which we furnished them; those data being the exact report of what we did and what we found on so doing.

Mr. Howland comments upon the course of the commission during the tests, in making repairs of any small defects which we might find, or which we did find, in the course of the experiments, which would prevent the series of experiments being carried to a conclusion, if from the imperfection of material or any minor imperfection of workmanship a meter should cease to operate, or fail to operate as it was evidently intended it should operate, before we had had an opportunity of really finding out whether the machine had merits or not. We considered we had a perfect right to do so, and, in fact, that it was our duty to make such repairs as could be readily made, to obviate those defects of structure, and enable the machine to be put through the complete series of tests.

Mr. Howland, in his comments, says: "The Commission provided facilities to test each meter under many of these varied conditions,"—conditions which are met with in actual practice,—"but in testing, they tested each metre under one particular condition, completed it, then took another condition, completed that, and so on, making the test under each condition complete in itself and not merging one test into another; whereas, a meter connected, say, with a four-story apartment house is probably for a series of hours never entirely at rest, but water is flowing through it at high velocity; then, at other times, at a velocity so slight as to hardly move the meter, and then at a different velocity, and so on, without any regularity or uniformity of the service; if, therefore, the Commission had arranged an apparatus by which these different conditions could, alternately, be brought to bear upon the meter and all without stopping, readjusting and again setting the meter, for a series of hours, and then have compared the weight of water actually passed with that indicated, I think it possible that some different reports in relation to some of the metres would have been made. Such a test would have taken additional time and expense, and perhaps the Commission thought of it, but did not have the time and opportunity to carry it out."

That was certainly the case. But even had we had more time I do not think we should have done it in the way suggested by Mr. Howland, for this reason: We started with no knowledge whatever of the meters, or what they were expected to do, or what they were desired to do. We thought, therefore, that the best way we could find out what they might be able to do was to try them while they were new, before they had been worn, and find out what they would do under each particular change of condition. Simply for purposes of convenience in testing with the apparatus which we had, we took each meter and tried it under the various conditions, before proceeding to another; and we did not make these trials continuous, for the reason that I can see no reason why the accuracy of a meter when passing a given quantity of water in a given time would vary from its accuracy while passing another quantity of water in the same time, if there were five minutes, or any interval, between the two trials. I can see no reason why there should be any difference, more than if the trials were continuous. And as to the matter of convenience, it certainly was much more convenient as we did it. There would be nothing against the method suggested by Mr. Howland that I know of, but I think the way which we adopted was more convenient. That is the only reason we had for doing

it, and that is the only apology we have to make for it, if any apology is needed.

Mr. Howland makes some comment upon the remark which we made as to the desirability or necessity of seeking for absolute accuracy in a meter for ordinary use. And certainly we *did* question the desirability of attaining, at a considerable expense, absolute accuracy in a machine which was to measure a material of very little value. There is no use in buying gold yard sticks to measure cotton cloth. It is simply a question of comparative economy. Of course it is always desirable to obtain absolute perfection in everything, but as a matter of economy does it pay to go beyond a certain limit in attaining that absolute perfection. The discussion which Mr. Howland goes into I have not had time to read over and digest properly, and therefore will pass it by without any further comment.

In testing two of the meters which we used, (which were rotary meters,) we stated the manner in which we tested them. They were both double rotary meters. One of them was run with its axes vertical, the revolution being horizontal,—and the other with the axes horizontal. Mr. Howland says he "knows of no reason why one meter could not have been tested in a vertical position as well as the other," and thinks "that the Commission made a possible error in judgment in not testing these two meters under the same circumstances as regards position." There *is* no reason whatever. There is no reason why we might not have taken every meter and turned it upside down, if we had seen fit to, except the reason that the meters were not *intended* to run upside down, and they *never are* run upside down in practice. So, in testing these two meters, and in testing every other meter, we ran them in the same position as they were intended to be run, and we obtained our knowledge as to how they were intended to be run, either by an examination of the machine, (in case no instructions from the makers accompanied it,) or in accordance with the instructions of the makers themselves when they sent the machine for test. And in the case of the meter which we ran with the axes horizontal, the meter came accompanied by no instructions whatever, except a request that in placing it upon the pipe we should so place it as to allow the water to pass through it vertically downward, instead of in any other position,—to do which it was necessary to place the axes horizontal. We gave the maker credit for knowing how he wanted his machine to be run, and that is our only reason for testing it in that position.

Mr. Howland says he would commend a careful study of this report to all interested in the subject. That is just what we wanted to have done. We gave in our report no conclusions carried to their final end, but simply the results of what we had found, in order that those who were interested in the meters might by a study of the record draw their own conclusions, and from the results so obtained find the means of improving their own machines. Had we drawn those conclusions and amplified them, we would have been open to the charge, whether justly or not, of endeavoring to set forth the strong points of some meters and the disadvantages of others, and that we studiously avoided.

Mr. Whitney, of Newton, likewise makes some comments upon the report, and one or two of his points I will have a word to say with regard to. In our tests we made two for accuracy. In the first, the experiments were forty-one in number, and then, after making a trial of the relative durability of the machines, we made another test for accuracy which covered but ten experiments. Mr. Whitney says, "There were but ten experiments in the second series, as against forty-one in the first. A more satisfactory basis for comparison could have been had by reducing somewhat the number of trials in the first test, and by making the second accuracy test a duplicate of the first." Had we made all the trials under all the various conditions which our apparatus admitted of, the number would have been between 180 and 190, and very likely they would not have been finished by *this* time. Consequently, when we had made the forty-one tests which we did, we were instructed by the Water Board, by whom we were employed, to bring the thing to a conclusion as quick as we could; that is, not to go any further into detail than we had already blocked out; and therefore we left off the remaining 140 of the first series and commenced upon our durability tests, and afterwards upon the second test for accuracy. A little study of the results of the first series of forty-one showed that the errors under very slightly varying conditions differed but very slightly, and we therefore thought that we could bring our labors to an end sooner by making a portion only of those forty-one experiments, and on that account omitted three-quarters of them. That was our only reason for having our second series shorter than the first, and the reason why we did not divide it up and make the two series twenty-five each, was simply because we had completed the first before we thought of reducing the number of the second.

Again, Mr. Whitney says: "Bench tests intended to produce in a short space of time the effects of long-continued wear in actual service are at best an unsatisfactory substitute for results obtained in practical use, and in the Boston test the quantity of water passed was much too small to show adequately either the wear of the valves and pistons, or the comparative durability of the various styles of intermediate gearing used in different patterns of rotary meters." Of course, if we could have carried our experiments to a greater length they would have been more satisfactory, but I do not know that they would have given us any better results. If we had had a longer test of durability we would have worn out more machines, but what we wanted was not to determine the life or limit of durability of each meter, but to ascertain relatively how each meter was wearing, or liable to be worn by continued use, and how that wear was liable to affect its accuracy. Therefore having passed through an amount of water which was equivalent to two years' average use, although it did not disable but one or two of the machines that we tested—(and I see now no reason for thinking we were in error in that conclusion)—we tested those machines again for accuracy, thinking we could thus obtain an idea of their relative wearing out by the effects of the use to which they had been put.

And Mr. Whitney virtually says the same thing in the next sentence: "Possibly had the durability test been carried farther, a less number of meters would have passed the trial successfully, and perhaps their relative standing

would have been changed somewhat." And that is so, because those which were worn entirely out would have been dropped from any further consideration. But it is possible that two machines may be run together and one absolutely wear out, and the comparison between them be stopped, without enabling us to tell just what the *relative* degree of excellence was; because the one which survived might have broken down the very next day had the test been continued further; while if we had stopped a day previous, while the two were still running, we could by an examination of their condition have determined, perhaps, their relative excellence; and they might both of them have been improved so as to have outlived much longer experiments and been made serviceable meters.

"The Commission concludes," continued Mr. Whitney, "that piston meters should not be used where the pressure exceeds fifty pounds, on account of the damage which the rubber bunters may receive from the blows of the plungers. It is doubtful if the majority using this class of meters will concur in this conclusion. At least one case can be cited where, with a maximum pressure of ninety-five pounds and an average of sixty pounds, 300 piston metres have been in use for nine years without the least trouble from this cause." I have not the slightest doubt of it, but we were obliged to draw our conclusions from the samples which were put in our hands for testing; and those samples show that in all of the meters which had the rubber bunters, and which worked with a considerable rapidity under the pressure which we used of fifty pounds only to the square inch, the bunters were materially affected, some of them being entirely destroyed, and others affected to a less degree. And in conversation with gentlemen who did us the honor to call in at times during our experiments, some of them stated as being the results of their experience, that when the pressure was a severe one, (exceeding that which we had,) they had found the same difficulty in their works; that the rubber bunters were injured and frequently destroyed by the effects of the concussion; and that being the case, as it might be done when the machine had just been examined and would not be examined again for some time afterwards, the unprotected head of the meter would be liable to be struck and possibly destroyed.

"In conclusion it may be said that it is doubtful if any test will settle for a long space of time the question what meters are the best. The weak points of the old kinds are being constantly strengthened and new meters being brought out, each of which (at least in the inventor's opinion) is the best in the world, but all requiring a trial to prove their worth or worthlessness." That is certainly so, and as we were not, as I said before, endeavoring to ascertain which meter was the *best*, I certainly have no further comment to make upon that point.

Mr. Tilden, also, reviews the paper and the report. He says in one place that "the test of service is the crucial test—the bench supplementary. The bench, for example, may prove that the shell or body of a meter is strong enough to stand a pressure of forty pounds, but does it prove it will stand eighty pounds, or the unknown pressure due to water-hammer?" It certainly does not. The question of the strength of the shell of the meter, although

certainly an important one, is not one, it seems to me, which in any way affect the excellence of the meter *considered simply as a machine;* for you can put any strength or any thickness or any thinness of shell on to any meter that exists. That is simply a matter for the designer of the meter to determine for himself in preparing meters to meet a particular market, a particular pressure. We found that some of the meters which we tried would not stand the pressure of ordinary use; the shell simply burst. We considered that the same as the other accidents to which I referred in the first place, that if there was a rupture which we could repair we would do it, and make the shell strong enough so that we could test the *machine* and not merely its *skin.* In one instance the machine burst the moment we put the pressure upon it; we hadn't *tested* it at all. In that case we simply took it off the bench, sent to the maker a statement of the fact, and asked him if he wanted to supply a new shell; and he sent a new shell, and we took the works out of the original one and put them in the new one, resealed it and began then the trial of the *meter.* The meter itself was the same meter which we had started with, but the shell was an entirely different one. That we stated in the report.

"An artificial test is not altogether reliable for the purposes of comparison." We were not making the test for purposes of comparison, and therefore there is nothing to be said about that.

"The test of actual use should comprise a number of meters widely located under every possible condition of service. High pressure and low, large flow and small, continuous and intermittent work, in short every variety attainable." That is true, but we had not the time to do it.

Those are the principal comments I have to make in relation to this discussion of my paper.

PROTECTION OF PIPES FROM FROST.

BY

E. R. Jones, Boston, Mass.

Yesterday afternoon I began to prepare a paper to read here this afternoon; I got part way through with it when I had an ill turn and went to bed, and I didn't get up till this forenoon, and the paper remains just as it was when I left it. I think the part that I didn't write would have been more interesting than what I did write, but I haven't even got that here. I have asked the privilege this afternoon of making a little explanation with regard to some remarks I made last February. At that time one of the members of the Association said he had understood that water would not freeze in pipes which were encased in rosin, and he asked if anybody had had any experience in that matter, and I replied that I had. I left the impression undoubtedly with the members present at that time that pipes encased in rosin were a failure, and I

thought I would like to explain my experience in regard to that, and I will make it very short, leaving you all to judge for yourselves if the subject is interesting enough to warrant my making such an explanation.

My first attempt at anything of the kind was on a two-inch pipe that was laid in 1854 under the channel to supply the Boston & Maine Railroad. It ran underneath the surface of the wharf, and then went down underneath the channel, and came up and went on again in the same way into the machine shop. That was encased in rosin. It was laid in a box, and I think the box was some six inches in the clear, the rosin being poured in. When it went down under the draw, this box was put down as far as the lowest tide would permit, and filled with rosin to the top, and so on the other side, and then when it got to the machine shop it went up overhead; and to make it sure it would not freeze they had large tanks made so as to keep the water running all the time. We were very careful to do the work as well as it could be done, but for all the protection afforded by the rosin and the tanks, the water pipe froze. Now, there is something to be said in explanation of that. I don't know but there was an unusually low tide and cold weather, and the frost caught it down below that point. I will merely suggest that for what it is worth.

The next time I tried the experiment myself at our works by making two boxes. I put the water pipes in one of the boxes and hung it in the middle with twine, so that the frost had no communication, or as little communication as possible, and filled it with rosin. The other one I made without filling the box with rosin, but putting a box on the outside filled with rosin. Well, it was one of those cases where, after I got it all done, there wasn't a cold day during that winter, so I had no chance to try it.

Some time elapsed before I had any further experience. When Atlantic Avenue was first constructed, instead of carrying the sea wall to the line of the avenue they carried it only to the line of the sidewalk, the edgestone. The sidewalk was, I think, twenty or twenty four feet wide.

A very wide sidewalk, any way; and, of course, the water coming up under the sidewalk, it was very cold there. I was away when they commenced it, and the Water Board concluded to put a double box there—that would have been something of a protection, but it wasn't of much service any way. Instead of filling that with rosin I filled it with what I consider a similar material; that is, I suppose the object of rosin was to prevent the entrance of dampness, when, of course, there would be no frost in it; I filled it with asphalt tar, a box about eight inches in the clear and twenty to twenty-four or twenty-five feet long. That winter they all froze up. I carried the pipe, by the way, so as to put a meter on, there was no chance to put a meter under the sidewalk, I carried the pipe away on the other side of the street and back again into the stores. The water froze up. I had given them advice, with regard to how the inside should be arranged, so the water should not catch there. You all know very well that if the water freezes and the ice catches in one place it will follow through the pipes a long distance, making ice little by little, for I don't know how far. I ought to know, for I have thawed out enough of them. However, these froze up. I saw the Superin

tendent and told him there was only one way I knew of, especially as a meter was on, and that was to let the water run a little and pay the difference and keep it from freezing. I suppose they have done that since, for we have had little trouble with them.

There were some more buildings built on the avenue, and I took this precaution, as I thought, in the little experiment I was telling of, putting them into a small box, making it air tight, and then filling with tar on the outside. They froze up. Well, I didn't know what to do. I don't know whether those froze from the street, whether they froze up through the box, or whether they froze up from the inside. They all told me they kept the fires burning there. There were three of them, and two of them froze up, and last February a man who occupied one of the stores,—Mr. Hicks,—came into the office, and told me that his hadn't frozen while the other two had, and he said he had always kept a good fire. Then I felt sure that the trouble was not in keeping a good fire in the building, and felt quite satisfied that that was a success. Well, I went off to New York and was gone a little while, and when I came back my first question to my foreman was, "What are you doing?" "Thawing out pipes." "Where are you at work to-day?" "Down at Mr. Hicks's." Well, that settled the matter. (Laughter.) I won't say it really did; I only leave it for you to judge whether it did or not.

That is as far as I have gone. Now, with regard to the freezing of water pipes, the question has been asked me a great many times how to keep them from freezing. Well, that is a pretty hard question for anybody to answer. If you will ask me the question and give me the circumstances in regard to any one pipe I might recommend something which would be a partial preventive. But there are three general rules with regard to this matter of keeping them from freezing, which you probably all know. One is to let the water run; that everybody in our town knows. The next is to keep the water out of the pipes. What I mean by that is, that on our wharves, which are the coldest places in Boston, the water passes up and then passes down again, and you can have a stop-cock to shut the water off always when you get through with it, and of course if there isn't any water in the pipes they won't freeze. The other is to keep the surroundings warm. Those are the only three ways I know of to keep water from freezing.

"CONSTRUCTION AND MAINTENANCE OF WATER WORKS."

BY

HON. CHESTER W. KINGSLEY, Cambridge, Mass.

Gentlemen of the New England Water Works Association:—I am to speak to you upon the "Construction and Maintenance of Water Works." My subject naturally divides itself into two parts, and I shall so treat it, as follows:

1st. The Construction of Water Works.

2nd. The Maintenance of Water Works.

An old cook book says in regard to the construction of a good fish dinner, "first

catch your fish," so in construction of a good water works, first, find an ample supply of good water. That this is a matter of vital importance the experience of almost all water works in the country will prove, aside from those located on a great lake, or on a never failing stream. The importance of this matter has often enforced consideration in a practical way, that at first was not thought to be within the bounds of probabilities. The experience of Boston and Cambridge are cases in point. Many others might be cited, but it is unnecessary here.

Having decided on the source of supply, there are four systems under which all water works in their construction may be classed and considered, to wit:

1*st.*—*The Gravity System.* By which we mean, when the water supply is high enough to furnish a natural head sufficient for all practical purposes. This is by far the most desirable and economical when it can be attained, and it will pay well to go further for a supply, and expend more on the original plant, to secure this permanent advantage over any other system.

2*d.*—*The Reservoir System.* By which we mean when the water must be elevated to furnish the necessary head for distribution, it can be pumped into a reservoir high enough for that purpose. A large reservoir is most desirable, where several days or weeks supply can be stored, giving the water a chance to settle, as well as to have on hand a supply in case of accident, or the demand for a large fire.

3*d.*—*The Standpipe System.* By which the water is pumped into a standpipe of sufficient elevation to furnish head for all places needing a supply. The pumping engine in this plan is so adjusted as to keep the water at a uniform height in the standpipe, changing its speed automatically to suit the fluctuations in the amount of water required from time to time. This plan like the next one, will require a much larger pumping capacity than is needed for ordinary daily use, as in case of fire a very large amount of water is required at short notice. We think this system should always have duplicate pumping power, to provide against accidents, and extra demands, and this should be in separate pumping engines.

4*th.*—*The Direct Pumping System.* By this the water is pumped directly into the pipes to the consumer, the pressure being maintained by an automatic arrangement connected with the engine, so that the speed of the pump is regulated by the pressure of the water in the pipes, very much the same as in the standpipe system. This system is used in many places where the land is level, and there are no highlands near upon which to make reservoirs. It will be seen at a glance that this system ought not to be relied upon without duplicate pumping power, and this in separate pumping engines, as the whole system hangs upon machinery, which may give out at any time.

The reservoir and standpipe systems may be used together, as is done in Cambridge, where the reservoir is not high enough to supply the highest places in the city, but with the standpipe added, all are well served.

The construction of water works has to a considerable extent become a

trade, or distinct operation, requiring special engineering, knowledge and experience, as well as special mechanical devices and machinery. Great improvements have been made, and are constantly being made in these things.

After deciding on the source of a water supply, the next thing to be done is to secure the necessary legislation, in order that the water supply can be secured, and such land as may be necessary, procured, either by purchase or otherwise taken by the right of eminent domain. These necessary steps may be taken by a city, town, fire district, or private parties seeking an act of incorporation. Several years experience on the "Committee on Water Supply," of the Legislature of Massachusetts, in connection with observation, has led to the conclusion, that whenever it will pay a private company to put in a water works, where one is needed, as a rule it is better for the city, town, or fire district, to get the proper legislation, and put it in themselves. A system has grown up in Massachusetts, at least, and we think elsewhere as well, by which private parties have made a business of going to towns, and manufacturing villages, and taking in with them some persons in the place, work up a sentiment on the matter of introducing water works. Their main argument being that private parties outside the place are willing to furnish all the means needed and put in the works, which will be a great benefit to the place. Sometimes this is true and may work well, but often we fear this is a specious reasoning for selfish ends. When water works are introduced in this way, the work is too often done in the cheapest way possible. The town is expected to, and generally does pay money enough for water for fire hydrants, and other public uses to pay the interest on the entire cost of the works. And this is not all. After awhile the town finds that it has made a mistake in not putting in its own water works, and they find in the Act, incorporating the private Company, there is a clause by which the town can buy the water works, and if it cannot agree with the Company on a price, it may take them and have the price fixed by a disinterested party in an equitable manner. This seems fair, and so far as the actual proper expenditure is concerned it is right. But when it is proposed by the town to avail itself of this privilege it is frequently found that the works were poorly built, with the idea of selling out to the town, and that now they need, to meet the increased demand, to be enlarged, and put in order at great expense. This the Company are unable, or unwilling to do. Then again the Company may and often does claim a large sum for the franchise, which cost them little or nothing to procure. These arguments used by those opposed to the purchase by the town, have much more effect than they are really entitled to. After all objections are made, we are still of the opinion, that when a private Company can make it pay, including the money the city or town pays to them, then the sooner the city or town buys, or takes the water works the better. We think a law should be passed providing that whenever a city or town takes a water works, no charge shall be made for the franchise beyond what it actualiy cost to procure it, as it seems plain that the State gave the franchise without charge on its part, for the benefit of the people of the town or city, and not to enrich a private corporation, by allowing it to make merchandise of her bounty.

We think a right public sentiment is growing in regard to the prior rights of cities and towns to use the waters of the Commonwealth, which she has granted for their use without paying damages for using them. We hail with great satisfaction the recent decision of the Supreme Court of Massachusetts, in the case of the "Watuppa Water Power Company vs. the City of Fall River," in which it was determined that the Commonwealth had the right to grant the use of the water which belonged to her, for the use of her children for domestic uses, without their being liable to pay damages to private parties, who claim that as they have long used the water for mechanical and mercantile purposes, without charge, therefore it belongs to them, and they must be paid for it.

Having secured the necessary legislation, and the water supply and the land needed, the next thing is to proceed and construct the necessary works. Which of the different kinds of works herein named you will adopt must be decided by the circumstances. The relation of the water supply to the place to be supplied being the principal factor, as a rule we should say with any system, the best is the cheapest in the end. In deciding what is best several things may be considered, and different persons will be likely to reach different conclusions as they view the matter from various standpoints. In regard to a pumping engine, one will decide that is the best which will perform the highest duty, another will decide on the basis of first cost. With him the cheapest is best. The basis we adopt is this: What pump will do the most work for the least money, taking into account, the first cost, the comparative duty, simplicity of construction, and cost of repairs; our experience has been with the Worthington, and the Blake Pumps, both of which we can recommend. There may be others equally good. We speak of these because we know them by a long and satisfactory experience.

In case of a gravity supply, or after your engines are decided upon in case of a pumping system, the next thing in order will be a reservoir if one can be had, or a standpipe if one is to be used. After that comes the piping to and from your distributing stations, through the streets to reach your customers to the best advantage. In regard to the pipes to be used, we prefer the cast-iron, coated pipes, as on the whole giving the best satisfaction. They are more easily handled, do not collect sediment and fill up, are more easily repaired, and tapped for supplies. This is our experience. We do not mean to say anything against cement pipes when they are properly made, but too much depends on the quality of the material used, and the workmanship in making them. We have not found such uniform good work with cement as with iron pipes. Whatever pipes you adopt, one thing must be carefully avoided, and that is, do not put in pipes that are too small. This is a mistake that nearly all the water works we ever heard of have made, and next to an ample supply of water, comes ample size of pipes. In this respect a great deal of allowance must be made for future growth, and extensions, as well as a good supply of water for fire purposes. It will be safe to make all your pipes, double the capacity you think you will need, and frequently double the size would be better still, especially in cities and large growing towns. In laying the pipes

care should be taken to lay them below the reach of frost. We have found that the frost goes deepest in hard trodden streets, and have had pipes freeze that were down five feet deep.

A sufficient number of gates should be provided for shutting off a part of the works at a time in case of repairs, and inspection for leaks. They should be located on a plan of the piping and plainly marked so as to be easily found; also blow-offs should be provided and marked in the same way. We think the best location for gates is on the property lines in the streets. A careful survey should be made, and elbows, and T's located and put in where hydrants are needed, or extension into other streets will soon be needed. After all is done a street plan of the works should be made showing the location and size of pipes, the location of all gates, blow-offs, and hydrants, &c., so that at a glance any part of the whole system could be seen and found on the surface without delay.

The streets being piped we next come to the supply pipes for the consumers. We use for the most part galvanized iron pipe, and they work well with us, for most of our work. In some soils, and crooked places we use lead pipe. We find a prejudice among our people against lead pipe, which we respect where we can. For fittings we use iron and composition, recommending the latter as cheapest in the end.

We put in standpipe shut offs in the sidewalks on each supply for our own use, and provide a stop and waste in the cellar for the use of the consumer.

Having completed our works we now come to the management, which is the next and last phase of our subject. One of the most important things is to have a *uniform system of management.* We think the best results are reached where the works are in charge of a Board, who should be chosen with reference to their qualifications for such work. They should be sound business men, of good judgment who have the interest of the city or town at heart. A water works should never in any way be controlled or influenced by political considerations, by which the management would be constantly changing with party successes and reverses, and thereby inexperienced men brought in to decide on matters which require long and practical experience to deal with successfully. The Board usually consists of three or five members, respectively chosen first for one, two, three, four and five years, then choosing one each year for the long term. This practically gives a continuous Board, with uniform management.

The next thing to do, and not less important to a successful management, is to secure the right kind of a man for Superintendent, as he is the chief executive officer of the Board. He should be a thoroughly practical man in regard to men and things—a man of expedients, who can meet and manage the many complicated things that are constantly coming up in water works, not only knowing how they ought to be done himself, but can instruct those under him, and infuse them with enthusiasm, and pride in their work. Such a man will have everything under him systematized,—a place for everything and everything in its place; a man for all work, and work for all men under him, his greatest personal ambition being to excel in the discharge of his duty.

Another important man in the management is the Registrar. This officer more than any other comes in contact with the consumers, when anything needs explanation; he must therefore be well informed in regard to all rules of the City Council and of the Water Board in reference to the water works, and he must explain and enforce them with firmness and kindness. He needs also to be a good accountant and have every consumer's account in such condition that at a glance it will show exactly how he stands.

Another very important officer is the pumping Engineer, who should be capable of thoroughly understanding his machine, and take pride in his work. He can do much, if well informed, towards keeping his pumps in order, and in the economical use of his steam power, using such appliances as have been found to be of practical value in connection with his work. In our experience we have found that the "Flinn Mercurial Regulator," attached to a damper in our chimney flue, a most excellent invention, by which the pressure of steam in the boilers regulates the draft, and thus the steam can be maintained at almost any desirable point, automatically. This also results in a most economical use of the fuel, and it has other advantageous results.

For ascertaining the height of water in our reservoir, and standpipe, which are a half a mile from the pumping house, we use mercurial gauges, which are graded to fourteen feet to an inch and give us the information very exactly.

Only a few of the many details in connection with a water works can be referred to here. We will speak of some. One of the most important is a thorough system of *Inspection*. After the water is introduced, to prevent unnecessary waste, constant care and inspection will be required to detect leaks in the street pipes, and leaks and unauthorized extensions on the premises of the consumers. At least twice a year a thorough inspection of all fixtures should be made, and compared with the books. We find this not only necessary but profitable, as many leaks in fixtures are found, and often careless and useless wastage detected which for the time being at least can be remedied.

An inspection of the pipes in the streets can generally be done best in the night time when the normal consumption reaches its minimum. This is done best by closing the gates, dividing the city into districts, and noting the effect. We have a chronograph connected with our reservoir which records the amount of water drawn out in any given time. We take the hours from twelve to four at night, and can at once detect if an unusual amount of water is being drawn. If we cannot find any good reason for it, we at once begin to search for the leak, and in the manner above described can usually detect and stop it in a short time. What we say about these things is from a Cambridge standpoint, and will be so received. Our consumption per capita is among the lowest. Our plan for keeping it so, may not be out of place here. After all has been done that can be done there will still continue to be a large amount of water wasted, and we do not believe that the best results will be reached in the proper use of water in respect to this matter, until a cheap and reliable meter is invented and introduced so that consumers will pay for just what water they use, and waste.

We think meters should be used *now* in all cases of large consumers, and

also where in the nature of the business a large amount of water might go to waste as in stables, and such places.

Water Rates. Different places adopt various systems for fixing water rates. We have found a simple and satisfactory basis for dwelling houses and the like, in the fixtures used, and special rates for hose, animals, and other purposes. All metered water is paid for by the hundred gallons; a schedule of all prices for general and ordinary uses is made and adopted for our guidance by the City Council, which takes from the Water Board so much of responsibility. We find this plan works well, for we have some customers who have the idea that they are not fairly dealt with in their water tax. To these we present a copy of the rates that govern us in the matter, and from which they may appeal to the makers of the water rates. In some charters it is required that the rates shall be fixed so as to pay the cost of maintenance, and also to create a sinking fund to meet and pay the interest and principal of any debt that may have been incurred in the construction of the works. In others the city or town is required to raise a certain amount every year for this purpose.

Drainage. Although this may be a step beyond the theme assigned to me, yet it is so closely connected with it that a word about it may be excused here. This subject should be carefully considered in connection with the introduction of water works, as after getting the water the next thing that presents itself is how best to get rid of it, after it has been used. It is a well known fact that a much larger amount of water is used after the introduction of water works than before. So important is this matter that Massachusetts has appropriated a large sum of money to enable the State Board of Health to continue a series of experiments to ascertain the best systems of drainage and sewerage adapted to different localities, and kinds of soil.

We have thus endeavored to present to you in a plain and simple way some of the results of our experience in connection with water works. We claim no originality of ideas, and doubt not that almost any one of your Association could have presented to you a better paper on the subject assigned to us. In this we rejoice, and hope that through the agency of such, and similar Associations as your own, that constant progress may be made by experience, in that knowledge which will make the water works of our country more uniform and better serve the people for whom they should be built.

WATER IN SOME OF ITS HIGHER RELATIONS.

Rev. D. N. Beach, Cambridge, Mass.

Happy is the man who works in a noble element. It is better to work in wood than in putty; in iron than in wood; in marble than in iron; in granite than in marble. It is better to lay hold upon the everlasting mountains than to delve in the merely productive prairie loam. It is better to train men than to train horses. It is better to touch the fountains of human action in men's hearts than merely to affect their minds.

You, Gentlemen, are engaged in the beneficent endeavor to bring into every home an abundant supply of pure water; to see that the industries and arts of man are stimulated by an ample, inexpensive and convenient supply of the same invaluable fluid; to insure our cities and towns from destruction by ruinous conflagrations, and thus to render the results of human effort more permanent, through the ready and ubiquitous fire hydrant; to adorn our haunts of work and life with beautiful fountains, the grateful reminders of those natural springs and cascades, which, wherever they abound, cause their whereabouts to be celebrated in story and in song; yes, even to see to it that horses and cattle, that cats and chickens, that alike the faithful house-dog,and the vagabond cur stoned by every other school-boy on the street, that the pet canary in its cage, and the noisy, hated sparrow under the eaves or in the hedge-row, shall not want, wherever man abides, water, pure, plenteous, and on every hand.

The work in which you are engaged is of inestimable value. It reduces the death rate. It promotes health. It induces cleanliness. It enhances comfort. It humanizes. It saves measureless toil. By your efforts, gravity, or an economic use of machinery at a central station, saves the long journey to the stream, the spring, or the well; saves the struggle with the bucket or with the pump handle; and saves these especially for the more toiling and suffering half of our humanity, women. You reduce hereby one far from inappreciable element in the "subjection of women."

But let me put this in the concrete. I see in my mind's eye a country farm. I see the father toiling fifteen or sixteen hours a day. I see the mother rearing her children, caring for her household, and meeting the thousand and one encroachments of a farm on the time of a farmer's wife. I mark the struggle to make both ends meet; to pay the semi-annual interest on a part of the purchase money of the farm, and to reduce the principal a little if possible each half-year. I see those great horses, and that herd of plump, hungry and thirsty cattle. Twice a day they are driven to the neighboring stream for water. In winter the ice is broken to quench their thirst. An idea dawns on that farmer. It turns itself over and over in his mind like a thing alive. Presently he acts, deliberately, decisively, and without wavering, like a man whom a thought has wholly mastered. Far up on the hillside, a long distance from anything that can contaminate, he digs a deep well. He digs it in a drought, in order to tap some never failing water vein. When the last blast is made, in rushes the precious liquid so fast that speed is necessary to do what needs doing at the bottom of the well. Out of that well, applying the siphon, he leads a stream of water with a heavy fall, first to the house, then to the barn. His neighbors laugh at him. Is the man mad? Will water rise sheer up out of a well of itself? Beside, how can the man, fighting with the wolf, afford the money? He can afford it. After long rumination upon the subject, he is sure that he cannot afford *not* to do it. And straightway perhaps $25 a year, interest on the money invested in this humble private plant of his, is almost his sole cost for a steady stream of pure water, always at hand, in the kitchen, in the laundry, and in the barn-yard. Whole weeks of toil, whole days of exposure in snow and rain, are thus saved, in the aggregate, to this farmer and

his household yearly. And, over and over again, in that household, grateful mention is made of the blessing of pure and abundant water, always running. The man thrives. The mortgage is paid. The family prospers. And water has largely done it. The neighbors cease to laugh, and begin to envy, admire, and emulate. By the help of water, this man, fighting his life's battle, is enabled to win. I have drawn no fancy sketch. I saw this little drama acted out. The digging of that hill-side well, and the laying of that long stretch of pipe, are about the first things I can remember.

And this beneficent service, you, Gentlemen, are doing on a larger scale—encountering the same objections, branded for fools, checkmated on every hand as far as possible, but by and by winning through the pure merit of what you advocate, and blessing at length not a single farm, but a town, or a great city, and making life easier and better, not for one household, but for thousands of them. I have been looking over the story of the introduction of the water of Loch Katrine, in the wild Scottish Highlands, into the great city of Glasgow, thirty-four miles away—perhaps the finest water supply ever given a metropolis—and the long fight against prejudice, self-interest, and stupidity, the gigantic labor, and the triumphant issue of the undertaking, were only, on a larger scale, what my father went through for his little farm and household, and what you are going through for households by the thousand and the ten thousand.

In all the respects which I have mentioned, as also in that which I have illustrated, you are great public benefactors. Life, health, cleaner and purer living, and living changed, in so far, from being a slave's life, you induce. You emphasize, moreover, the principle of co-operation. By combining capital and contributions through a water rate, you send a common good into every street, into every house, into every room, and to every mouth and human frame. Happy men, I pronounce you.

But I am here to say that you are happy men, also, in the nobility of the material in which you work. That with which you have to do is a thing nobler than can be told. Of the nobility of it, and especially of some of its higher relations, I am to speak to-day, telling you nothing which you may not know already, but trying so to group and emphasize certain points as, if possible, even more than ever to make you realize, in their light, how happy, how fortunate is your vocation.

I need not remind you, then, that the material with which you work covers not far from three-fourths of the globe, a thing easy to say, but hard to realize, even after spending many days on the vacant, trackless ocean; that what we call the "broad continents" are really only restricted islands and jutting peninsulas, girt about and laved ever by "the inviolate sea"; that, as regards the constitution of things, five-sixths of the bodies of animals and of ourselves are water; that water averages to constitute about the same proportion of fruits and foods; that vegetable substances hold it largely in composition; that one-fourth part of the vast amount of limestone in the world is water; that water enters freely into many other minerals, so that it is estimated that certain very abundant rocks of North America and Great Britain contain

water equivalent to seas of the area of those rocks and nearly a mile in depth; and so that the total of rock-included water in the world approximates the amount in the oceans themselves; that water pervades, also, the air we breathe; that, in short, it is to be found in nature at almost every turn.

Nor need I remind you that this its all-pervasiveness might almost be expected and predicted from its peculiar composition. It is now hardly more than a century since this secret was discovered. So nicely are its elements combined, so potent and so closely wedded are they, that, until that time, water was supposed to be an original and simple element. On the contrary, it was then discovered, as you know, that water is made up of two of the most powerful and important of the simple elements, viz., of one volume of oxygen combined with two volumes of hydrogen, or, by weight, of eight parts of oxygen and one part of hydrogen. The ratios are themselves striking, including two and its cube, and three and its square, viz., oxygen one-third in volume, and eight-ninths in weight. So perfect are these ratios and this blending, that water can only be resolved into its elements, by great stress, as, for example, by extreme heat, or by electricity; and that, when the combination is restored, a violent report ensues, and great heat is generated. One of water's most important relations is that to heat: and yet so remarkable is the blending of its elements, that, while both of them are highly inflammable, when combined they are the great foe of fire, and the great mollifier and utilizer of heat. Thus are the very fire elements empowered to conquer and use fire. I recall to your minds these striking chemical peculiarities, as preparatory and prophetic, if I may so say, of the great part which water plays in this universe.

This all-pervasiveness of water, and this its remarkable constitution, go well together with two of the more obvious utilities of it, which, however, hardly require to be more than mentioned. One of these is its power and service as a solvent. Nothing else is so universally that. In the language of another, "as it circulates—soaking, trickling, flowing—it filches an atom from this and an atom from that, becoming more and more charged with foreign matter, until it reaches the ocean." The same writer tells of a certain Massachusetts pond where three-one-hundred-thousandths of the water consists of dissolved matter, a little less than half mineral, and the remainder organic; and assures us that a stream from that pond, after running a dozen miles, has dissolved so much further matter into it, that "it has nearly twice as much organic matter and more than twice as much mineral matter as it had at the pond." This solvent power is not only purifying, but it enables water to become the great go-between, if I may so say, and express messenger of the material world. Indeed, by this property, it becomes the great nurse, too, finding for vegetation its food from a thousand sources, and conveying the same to every fiber, and serving as the prime auxiliary of nutrition in animals.

But there is something far subtler than ordinary matter, in respect to which water is also at once the express messenger, and the tender, waiting nurse. I refer to caloric. For this globe has coursing about it a gigantic circulation of hot water, and is fitted up with a mighty steam heating apparatus, by the help of which not only are the tropics kept from boiling, and made habitable,

but the poles are so mollified as not to be altogether lifeless; while certain high latitudes, as notably our Mother Islands, instead of being frozen half the year like Labrador, are rendered temperate and delightful. Moreover, locally, the moisture of the atmosphere greatly tempers the sun's rays, cools the air with refreshing showers, gives the grateful dewiness of the warm nights; and, in cold weather, blankets field and lake and river with ice and snow, while the very process of freezing liberates great quantities of heat, thus tempering even the most rigorous and polar winter.

I have referred thus far to the wide diffusion of water; to its remarkable constitution, which might make us expect great things of it; to its being the most universal of solvents, and thus the great go-between and nurse of nature; and to its marvelous relation to caloric, by which, though it is, in itself, "of fire compact," it is at once a heater and a cooler, a reducer of tropic ardors and of arctic rigors, and the beautiful ministrant both to summer and winter to make them relatively mild and beneficent. But I have wished only to bring to your thought, and arrange in a natural order, these four fundamental aspects of water—aspects with which you are more familiar than I—in order to make them an agreed upon point of departure for thinking of water in three other aspects, which I have ventured to call especially its "higher relations," which are not, perhaps, as commonly thought of as are the others, and which, with the four points already indicated, give us seven thoughts about water—a natural and "perfect" number of them—which I shall be glad if I may leave with you.

1. The first of these higher relations is, *its world-making, or geological relation.* In handling it, and the others, I can only, of course, note most cursorily a few facts, leaving you to fill up the outline, as in a sketch map.

Under this head, then, we may say, for substance, that water has been a principal agent in preparing the earth for the successive orders of life, and has been a principal architect of the world as we now know it.

The abrasion of the earth from the more hardened, crust-like condition in which its cooling left it, into particles which we may think of as sand or mud, had water, heated and seething at the first, for its great promoter, the solvent power of water, and its distributing power, coming largely into use in this connection. There came thus that earliest soil, oozelike in its nature, out of which sprang the gigantic flora of the coal periods not only, but the earliest forms first of vegetable and then of animal life. Water, in short, dissolved and distributed the particles upon which, as if they were a gigantic marsh and farm, the earth began to vegetate and breed.

The process of stratification, the rock-making, which began to change the oozelike, weltering world, into the ordered, defined, and charactered world which we now know, also had water for a main agent. The tremendous masses of rock, tens, scores, and hundreds of thousands of feet in thickness, as we may know from following their tilted succession, mile after mile, and from identifying the same in many lands these masses twisted, distorted, bent, folded in on themselves, and again escaping into orderly succession—were largely deposited under the sea by marine action. Considerable parts of the

present Atlantic ooze, for example, disclosed by deep-sea dredgings, are identical in their nature with solid, dry, limestone rock. It is such rock a-making. Much rock is, however, igneous. There are great lava deposits. There are trap dikes. There are granite masses. Here fire interfered. But water interplayed with fire. The water deposits, on the one hand, formed the mold, so to say, for the flowing, igneous rock. And, on the other hand, one can hardly conceive the gigantic upheavals of water-deposited rock strata, with their twistings, contortions, and foldings, to have occurred without some primordial and titanic use of the hydraulic lift, and of steam force at work in connection with the central earth fires. Water thus largely built the rock-based and rock-ribbed lands which man now occupies so securely.

I have mentioned limestone. Its distribution, either apparent or concealed, is world-wide. It helps form our very bones. It is indispensable in the present economy of the world. But water made that—water, and great varieties, forms, and multiplications of marine life. Nearly if not quite all limestone had its origin in such life, which water nourished. Go, for instance, into those great marble quarries of Vermont, where they cut out the snowy stone as if it were cheese. The material of those vast masses and cavernous halls, was once the shells of marine animals. Thus water, begetting and nourishing this type of life, made for us, organically, this indispensable substance.

After this particularly vital and constructive service of water in geology—one of the most curious and mysterious of all—I wish to refer to a work of water visible to us on every hand, and to be found in large parts of the world. I allude to the action of ice. Either by glaciers formed upon exceptional elevations of land in the northern and southern hemispheres, as maintained by Agassiz, Dana, and others; or by icebergs plowing through shallow northern and southern seas, as maintained by Lyell, Dawson, and others, great portions of the world have been molded. Geologists of the former opinion point to the marvelous glacial action now going on in Switzerland to illustrate their hypothesis; while those of the latter, maintain, that the Newfoundland Banks, could they be lifted a few hundred feet, so as to be visible above the Atlantic, would disclose phenomena like those sought to be accounted for by the other view. Whichever supposition is correct—and the former seems the more reasonable, though the latter may also have a basis of fact for such regions as it could apply to—all North America to a point considerably south of the latitude of Boston, and corresponding lands in Europe and Asia, have been cast into their present form largely by ice. The hills of Boston, now to a great extent leveled, the knolls around Fresh Pond in Cambridge, and a series of similar hills, with nearly a uniform trend of direction, spread over New England, are nothing but heterogeneous debris loosely thrown up by the rushing waters of melting and plowing glaciers. The New England lakes, mainly shallow, with gravelly bottoms, were, in many instances, originally tracts of ice of a corresponding extent, graveled over by running water, and thus for a time preserved unmelted at the general surrounding level, but subsiding as the buried ice slowly melted, until they formed lake basins. What we call bowlders, are, as you know, bits of ledge which the ice has carried and dropped here and there

at its own sweet will. They can often be identified with ledges to the north of them, whence the glaciers detached them. Our zone, in brief, was largely carved and molded by this agency—the cold, icy sculptor which the waters created. It was my happiness this summer to penetrate for the first time toward the South of Europe, and to observe this same process now going on in the Alps. I gazed with indescribable emotions on the mighty pyramid of the Matterhorn, so precipitous that the snow seems with difficulty to cling to it, nearly fifteen thousand feet high, and yet water worn. I looked with awe and admiration at the glacier work to be seen in process at frequent intervals along the valley of the Visp, and in the vale of Chamonix. Lower down, as in the Rhone valley, the more ordinary alluvial work of water might be seen going forward, more grandly indeed, with rush and roar, and with waters greenish and grayish from the minerals held in heavy solution, but along no different lines than in the valley of our own Charles.

2. The second of the higher relations of water about which I ask you to think, is, *its history-making, or, in a broad sense, its political relation.*

Several of the early great empires were associated with rivers—with the Nile, the Euphrates, the Ganges. There is a broad, general truth in the Genesis narrative, however it is to be interpreted, which tells us that from the first dwelling-place of men four rivers were parted. For, down from the sources of streams, out of the highlands, following the river courses, men everywhere descend From the Persian uplands they cover the alluvial Chaldean plains; they follow the Alpine water ways into Italy; they make the Rhine point like a finger board the direction of Anglo-Saxon civilization.

The influence or relation of which I speak is illustrated by the civilizations which nourished themselves in the lands bordering the Mediterranean. There was the civilization of Egypt, partly a civilization of the Nile, partly of the sea—mystic as the mysterious origin of its worshiped river, sensuous as its own Nile Delta and warm sea border. There was the Greek civilization—open, clear-eyed, acute, luminous, like its sunny islands, its sparkling bays, its jutting peninsulas. There was the Roman civilization, as rugged and masterful as the Apennines thrust rib-like into the bosom of the Mediterranean. There was the civilization of Palestine, at the head of that great inland sea, at the touching point of three continents, and aspiring accordingly to dominate and bless nothing less than the whole world.

If this seems fanciful to you, this mighty impulse of descending streams, of great rivers, of sparkling archipelagoes, and of bordering seas, in giving a type to national life, and in helping set forward world-historical movements, I ask you to think of two or three more modern instances.

What, then, let me ask, was the Anglo-Saxon fatherland? It was Teutonic. Why, then, do our brothers of Germany, and of the low countries, stay mainly on their own soil, or colonize only feebly, while we ourselves, having been first transferred to the Mother Islands, have colonized the world, are erecting mighty nationalities on three continents, and are giving to the whole world our institutions and our speech? Before you answer this question I ask you to sail along the shores of the Continent, opposite Great Britain; to note that

there is hardly a respectable natural harbor on the French coast; to note how remote and difficult of access are the better harbors of the North Sea and of the Baltic; and then, crossing the Channel, to observe that our Mother Islands are fairly fringed with bays, inlets, safe harbors, and inviting river mouths. Sail up the Irish coast, for example, with this distinction in mind. The whole coast configuration, the whole maritime quality of these Islands, were a perpetual predisposition to the sea, to its hardy employments, to its openness of mind, to its far-reaching adventure. Water, and the water impulse and opportunity, are the answer, physically, to the question why the Anglo-Saxon civilization, which, indeed, had within itself elements mightily adapted to the same end, is erecting great nationalities on three continents, and is imparting its spirit to the world.

But let us keep within the lifetime of our own generation. Go back, in our own country, to 1860. Why was it, in all the stress and conflicting sentiment of that stormy period, that North and South did not separate, like Abram and Lot dividing the land? One great reason, one conclusive practical reason, one unanswerable argument to multitudes who would not have stood upon theory, was the simple natural fact that a mighty river coursed from North to South through the alienated sections; that the natural flow of waters, and the natural dip of water-sheds, pointed out that this ought to be one land, not two; and that it was impracticable for it to maintain itself as two.

Or go back to 1870. There is a magnificent river, almost a second Rhine, descending from the Southwest by a Northeasterly course to the Rhine, and joining it at Coblenz, viz., the Moselle. The two streams are for all practical purposes, one. The country drained by them is the same in character. The Moselle belonged within the old German frontier. All the Rhine love was shared by it. But France had claimed and held the Moselle. The struggle of 1870 came. Then the old river passion awoke. That fair valley was wrested back. In the great German national monument, far up on the heights overlooking the Rhine at Bingen, where colossal bronzes have been erected as a memorial of the uprising and unification of the German peoples in that war, one member of the group is a figure representing the Moselle, won back to its sisterhood with the Rhine. But the river love and the river spirit, expressed thus in bronze, were even realer and more constructive than the statue indicates in that fierce national struggle.

3. The final higher relation of water which I mention, is one difficult to be defined, and of which I can take time to give only two illustrations; but it is as real and mighty as any of the others. I refer to *the power of water on the human imagination*. And I think I need hardly contend, before a company as intelligent as this, that genuine and profound influences on the imagination are among the most powerful springs of human conduct.

I ask you, then, first, to think of the Arthurian legends. There is a great mass of them. Their principal home is the British Isles. Their constructive thought is, the reappearance of Arthur, in the ages to come, to bring in days better even than the old days of that king,

and of his table round. They have been cast into perhaps their best practical, as certainly into their most poetic form, in Tennyson's Idyls of the King. Any one who has studied them, and who is at all familiar with the spirit of Anglo-Saxon history, will, I think, admit, that they well typify the best movements of that history; that they are true race legends; and that much of their promise bids fair yet to be practically fulfilled. Now the point which I ask you to notice is, the play of springs, waters, and inland lakes in them. They are water and insular legends. Their delicacy, their purity, their freshness, their promise, their sense of mystery and of fate, their sense, too, of goodness, of trust, and of love, are water born. They are genuine idyls. But they are insular, they are of springs, streams, and inland lakes. These begot those. From the waters, that is to say, came the thoughts, the ideals, the aspirations. The whole intellectual and moral fabric, so true to our history, and so prophetic of its issue, is inseperably connected with the power of water over the imagination.

But, as you may consider this too vague and general, I ask you to think of a phenomenon of our own century. Just at its dawn two young men, warm friends, took a journey together into the region of the English Lakes, then little frequented—and now, by the bye, about to be utilized for the supply of water for the great City of Manchester, perhaps seventy-five miles away. The young men were more than charmed, they were fascinated, by the seclusion of those vales, by the beauty of the wild glens, by the fantastic shapes of the mountains (themselves water-carved), by the humidity of the region which the perfect drainage of the soil hindered nevertheless from being wet, by the play of cloud, mist, and sunlight, but especially by the lakes themselves, and particularly by Grasmere and Rydal Water. One of the young men, by far the greater genius of the two, was enamored instantly, and kindled the slower susceptibilities of the other. The former of these young men was Samuel Taylor Coleridge. The latter was William Wordsworth. Within a year Wordsworth settled by Grasmere, and in its neighborhood he spent a long life. Coleridge settled by Derwentwater, not far away, but after some years removed to London. It would be easily possible to show that the lives of both these men were definitely affected by the then wild lakes; that the lakes entered into their thinking and their theories; that, in the case of Coleridge, his power over English and American thought in the first half of this century—a power so great that it can hardly be estimated—was largely contributed to by the lakes; and that, as for Wordsworth, who lived by Grasmere and Rydal all his life, and now lies in Grasmere churchyard, and who marks a new epoch in English poetry, the lakes were as the water of life to him. Of Southey, De Quincey, and Scott (whose own lakes were, however, those of the Scottish Highlands), of Wilson, and of Thomas Arnold, much might be said in the same direction. There was never really any "Lake School," except in fancy, but there was a mighty, deathless lake *life*—whose power in English literature and in Anglo-Saxon living will not soon die. And here was done for a few rare minds by these inland lakes and streams, visibly, palpably, and in a way vastly affecting our age, what less palpably, but not

less really, was done, by the operation of the same causes through the Arthurian legends, for our Anglo-Saxon people during many centuries.*

With reference, then, to water, I think I may remark, in conclusion, that, when we have followed it into some of its higher relations, we shall find nothing strange or incongruous, but something, the rather, eternally true, in the saying of the Apocalypse, that, even in Heaven, there is "a river of water of life."

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*The reader will observe that the two illustrations are drawn from within the ancient northern glacial belt. It would have been interesting to draw a third from within the same belt on our side of the Atlantic. What Lake Walden and other New England lakes similarly formed, and their associated streams, did for Thoreau, Emerson, and Hawthorne, there is no estimating. Indeed, perhaps Hawthorne is never so much at home in any of his foreign writing as in his English Lake Notes. The waters of the old ice lands, having their own peculiar setting and character, need to be studied in relation to the history of the imagination, and of national spirit, by some one expert both in glacial action, and in literature and folk-lore. Were all the facts known, it would probably appear that the lakes and streams of this belt, presenting as they do a singular combination of thought-impressing elements, have, from the times when man began to think, over and over again, induced such personal experiences as the Arthurian legends seem to imply, as the Coleridge-Wordsworthian lakes passion has put into biography, and as Thoreau, the New England solitary, lived out. There seem to have been analagous experiences among our aborigines. It is doubtful if Scandinavian literature can be explained without them. The Tell legends spring ashore, as it were, from the Lake of the Four Forest Cantons. How well the ice wrought! How much mightier than Merlin's is the water's enchantment in the old ice lands!

OBITUARY.

WM. S. BARBOUR,—City Engineer, Cambridge, Mass., died February 24, 1889, aged 54 years. Joined this Association June 19, 1884.

Mr. Barbour was engaged in general engineering work in Cambridge and Boston until 1875, at which time he was chosen City Engineer of Cambridge, which office he filled with signal ability. Among the last works which engaged his attention was the construction of the Stony Brook Water Works Dam.

The deceased was of an unassuming and retiring disposition, and possessed of a gentlemanly bearing, which won for him many fast friends who will deeply mourn his demise, depriving, as it has, the city of a faithful official and this Association of a valuable member.

New England Water Works Association
Membership Roll.

MARCH 1st, 1889.

NOTE.—The secretary requests to be advised of existing errors or changes of address from that which appears in the following list:

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Alexander, George
74 Federal street, Boston, Mass.

Andrews, Frank A.
Assistant Superintendent, Nashua, N. H.

Allen, Charles A.
City Engineer, Worcester, Mass.

Allen, Charles F.
Treasurer, Hyde Park, Mass.

Allis, Solon M.
Superintendent, Box 964, Malden, Mass.

Ayres, Henry W.
Chief Engineer, Hartford, Conn.

Babcock, Stephen E.
Hydraulic Engineer, Little Falls, N. Y.

Bacot, R. C., Jr.
Superintendent Meter Dept., Hoboken, N. J.

Batchelder, George E.
Registrar, Worcester, Mass.

Bagnell, Richard W.
Superintendent, Plymouth, Mass.

Ball, Phinehas
Civil Engineer, Worcester, Mass.

Baldwin, Charles H.
Box 2410, Boston, Mass.

Barbour, Wm. S.
City Engineer, Cambridge, Mass.

Barney, W. H.
Superintendent, Milford, Mass.

Barnes, Everett
Superintendent, Westerly, R. I.

Battles, James M.
Lowell, Mass.

Beals, Joseph E.
Clerk and Registrar, Middleboro, Mass.

Bickford, Nathan B.
Superintendent Water Works, O. C. R. R., Boston, Mass.

Billings, Wm. R.
15 Harrison street, Taunton, Mass.

Birkinbine, Harry
Superintendent, Council Bluffs, Iowa.

Bishop, George H.
Civil Engineer, Middletown, Conn.

Bolling, Charles E.
Superintendent, Richmond, Va.

Boyce, W. C.
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Brackett, Dexter
Superintendent Eastern Div., Boston W. W., 221 Federal street, Boston, Mass.

Brady, John G.
Commissioner, Worcester, Mass.

Brand, Junius A.
Superintendent, Norwich, Conn,

Brinsmade, Daniel S.
Civil Engineer, Birmingham, Conn.

Broatch, J. C.
Superintendent, Middletown, Conn.

Brown, Arthur W. F.
Registrar, Fitchburg, Mass.

Brown, Edward H.
Superintendent Nevada County N. G. R. R., Grass Valley, Cal.

Brown, J. Henry
3 Tremont street, Charlestown, Boston, Mass.

Brush, Charles B.
Engineer and Superintendent, Hackensack Water Co., 13 Newark street, Hoboken, N. J.

Burnham, Albert S.
Superintendent, Revere, Mass.

Caldwell, Joseph H.
Registrar, Mystic Division, Charlestown, Boston, Mass.

Carroll, F. B.
Box 630, New London, Conn.

Cate, E. W.
Water Commissioner, Newton, Mass. Address 113 Devonshire street, Boston, Mass.

Chadbourne, E. J.
Superintendent, Holbrook, Mass.

Chandler, Charles E.
City Engineer, 161 Main street, Norwich, Conn.

Chandler, Charles F.
Prof. of Chemistry, School of Mines, Columbia College, New York city.

Chaplin, W. S.
Professor of Engineering, Harvard University, Hammond street, Cambridge, Mass.

Chace, George F.
Superintendent, Taunton, Mass.

Chase, H. S.
Superintendent, Great Falls, N. H.

Chase, John C.
Superintendent, Wilmington, N. C.

Clark, Ezra
President and Superintendent, Hartford, Conn.

Clark, Jonas M.
Superintendent, Northampton, Mass.

Coburn, Walter
Lowell, Mass.

Cochran, Robert L.
Superintendent Water Works, Nahant, Mass.

Codd, William F.
Superintendent, Nantucket, Mass.

Coffin, Freeman C.
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Conant, H. W.
Superintendent, Gardner, Mass.

Conant, Whitney
Secretary Water Co., Long Branch, N. J.

Coggeshall, R. C. P.
Superintendent, New Bedford, Mass.

Coolidge, S. S.
Water Commissioner, Bellow's Falls, Vt.

Crehore, Dr. C. F.
Water Commissioner, Newton, Mass. Address Box 1252, Boston, Mass.

Crandall, F. H.
Superintendent, Burlington, Vt.

Croes, J. J. R.
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Cunningham, W. B.
Superintendent, Trinidad, Col.

Cushing, Lucas
Asst. Superintendent, 221 Federal street, Boston, Mass.

Darling, Edwin
Superintendent, Pawtucket, R. I.

Davedson, James
Superintendent, Box 246, Central City, Col.

Davis, F. A. W.
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